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ADULT EDUCATION IN GREAT BRITAIN

WRITING on "Democracy and its Discontents" in the June issue of *Encounter*, Mr. M. Beloff argues that the outstanding event in the political history of the past hundred and fifty years in Britain is the development of the Civil Service and of an educational system which has taken enough account of the claims of talent to enable it to create a race of administrators capable of maintaining the consistency of government in spite of the advance towards democracy. Implicit, if not explicit, in this argument is the plain truth, which no party politician dare admit, that wise government is impossible if the discretion of Ministers placed in office by a political party majority is fettered by having continually to consider the effect on voters of taking the measures which are clearly indicated by facts known to them in office but which are unknown, and cannot be made known, to the electorate, even if the electorate were able to appreciate their significance. Efficient and skilful government is, in fact, impossible if many decisions to-day are not removed from the range of popular choice.

Mr. Beloff does not, however, regard the excessive power of the party system or decrease in the prestige of Parliament as the real menace to the stability of British parliamentary institutions to-day. Rather it lies in the possibility of a serious attempt to achieve literal educational equality and to kill the élite which has enabled us to afford the luxury of popular government. The claim that British democracy has been so successful largely because it has become undemocratic is not likely to pass unchallenged. It will at least be asked what has been the cost to the quality of public life and to the wisdom of public policy. Nevertheless, whatever reservations are made as to the full validity of Mr. Beloff's argument, it emphasizes the importance of education for leadership and of maintaining the highest standards of training in the schools and universities from which our future ministers, administrators and experts are drawn. In the context of such episodes as Crichel Down, the words of the University Grants Committee in 1936 regarding the responsibility of the universities are indeed pregnant: a university should stimulate and train its students "at least to think, and to think strenuously about the great issues of right and wrong, of liberty and government, on which both for the individual and for the community, a balanced judgment is essential to a rational life".

While Mr. Beloff, at least by implication, thus emphasizes the importance of education for leadership and the danger inherent in any educational policy which by levelling down hinders the emergence of such an élite, Sir Ivor Jennings's recent exposition of the working and institutions of British democracy, "The Queen's Government", points to the importance of education at the other end. He finds an explanation of the stability of British institutions rather in the fact that the coming of universal suffrage has

placed the balance of political power in the community into the hands of the lower ranges of the middle class, mainly salaried employees and small proprietors, whose votes determine which political party shall win the relatively few marginal seats. The interest of these voters is on the whole against violent change, and since political parties must appeal to these voters, violent conflicts of principle are abated and a high degree of uniformity imposed on party programmes.

Whether or not Sir Ivor Jennings's theory be correct—and his view does not necessarily exclude Mr. Beloff's—it indicates the importance of adult education if the issues of the day are to be resolved more impartially and factually and less according to party political doctrines. The stress lies on instruction of the electorate rather than on parliamentary discussion if the findings of the expert are to be used fully in shaping policy. Much more practical thinking about the functioning of Parliament and the relations between Parliament and Minister and administrator and expert is clearly required than Mr. Herbert Morrison foreshadowed in his recent book, "Government and Parliament: Survey from the Inside". The Crichel Down debate in the House of Commons on July 20 at least indicated an awareness of such issues and some readiness to examine them.

While the time is opportune for a re-examination of the working of our Parliamentary institutions and of the philosophy upon which they are based, that examination should be conducted with reference not merely to the structure of government itself and to the men and women responsible for the task of government, whether Ministers, Members of Parliament, or Civil Servants, but still more to the capacity and limitations of the public who placed them in power. In essence it is a re-examination of the problem of power and influence within the framework of a democratic society under the impact of technological change, and the critical factor is likely to be at least as much the receptivity and adaptability of the average citizen as the wisdom, initiative and ability of those responsible for the task of government. If the Technical Assistance programme or the Colombo Plan have done nothing else, they have demonstrated how sharply technical assistance and economic advance in the relatively undeveloped areas of the world are limited by the general standard of education and understanding of the peoples of those areas, as well as their capacity for self-discipline and co-operation.

Those factors set the limits of government action no less sharply among the more advanced nations. If Britain, for example, is to take full advantage of the opportunities of economic development and of raising the standard of living which technological development has made possible, much will depend on the ability of statesmen to secure public understanding and co-operation in the changes, the displacements and sacrifices that may be involved. There is no room for the demagogue in such developments, or in such institutions if the Social Welfare State is to endure. An educated electorate is as essential a condition as wise and competent leadership.

Recognition of this and of the dangers inherent in the present position lies behind much of the concern with which the Government's proposals in regard to television and broadcasting are regarded by responsible leaders of all political parties and walks of life. It is also a reason why educational policy is so important an issue. Even the persistent shortage of science teachers is a factor to be considered here. The direct effect of that shortage is to handicap plans for the expansion of technological education, for example, and to make it more difficult for the nation to obtain the increased numbers of well-trained scientists and technologists who are required in industry, in government service and in the universities and technical colleges. It also affects, however, the recruitment of teaching staff for such institutions, and the number of those coming forward from the schools to enter on careers in science and technology.

But a shortage of science teachers in the schools does not merely affect the supply of those who are willing and ready to undertake studies in science and technology at the university—or technical college—level. It limits the number of those whose general education enables them to leave school with some understanding of what science is—and is not—and of the bearing of applied science on everyday life. This effect, moreover, is likely to be accentuated by the general shortage of teachers required to meet the substantial rise in the school population between now and 1960 by up to some 20 per cent on the 1950 figure. From 1960 onwards there are likely to be ten per cent more children in the schools than in 1950, and unless the present annual increase in the number of teachers is fully maintained, the proportion of children receiving education even of the standard provided in 1950 is likely to fall. Prospects of a ten per cent increase in the number of those entering on a scientific or technological career merely through the overall increase in the school population are slender, even if the shortage of science teachers is removed.

From this point of view a determined effort to reduce the size of classes at least below the regulation forty might be well worth the price demanded. For the next generation, however, the standard of public understanding will depend in large measure on adult education. Indeed, debates on education in the House of Commons suggest that the measures required to avert a fall in the standards of primary and secondary education by eliminating the over-size classes and to secure the wisest use of our limited reserves of trained man-power must wait on the support which an informed public opinion could give.

Since the county colleges for further education now appear to be a remote possibility of the future, the main responsibility for adult education must lie with existing agencies. Admittedly, as Mr. Ernest Green points out in his book "Adult Education—Why this Apathy?"*, adult education must begin in the schools, and the desire for liberal education, as distinct from mere vocational training, is either

* Adult Education: Why This Apathy? By Dr. Ernest Green. Pp. 146. (London: George Allen and Unwin, Ltd., 1953.) 15s. net.

stimulated or stifled at the time of leaving school. This situation may well have to be accepted for the next ten or fifteen years. By that time we may have, as he suggests, enough teachers, better trained and with wider experience of life, adequate buildings and equipment and a curriculum which is less concerned with the job a boy or girl is to enter and more concerned with their minds, character and personality; in that event, the schools will indeed be producing citizens in the schools instead of clerks, shop assistants, apprentices, etc.

In the meantime, we have to face a situation in which the schools are still failing to lay the foundations for good and responsible citizenship and to strengthen the moral and spiritual values on which such citizenship is based and the preservation of all that is best in a cultured, democratic way of life. In this context the concern with which the passing of television under influences that are not primarily swayed by the idea of public service is regarded can be understood. As the Government's White Paper admits, "television has great and increasing power in influencing men's minds", and the Beveridge Report had earlier recognized that broadcasting could increase the danger of the passive acceptance by the masses of orders given to them and of things said to them. Such passivity is a serious danger to democracy and free institutions to-day, and one which television, even more than sound broadcasting, encourages.

Moreover, this concern over power and responsibility in television takes place at a time when, as various re-examinations of adult education, prompted in part by the celebration of the jubilee of the Workers' Educational Association, have shown, there appears to be a decline in both the efficiency of existing means of adult education and in the interest taken in them. Dr. Green, for example, points out that approximately one in four of the school leavers covered by his inquiry make no apparent effort to follow up their school experience, even in the direction of vocational training; and of those who do, nine out of ten appear to be uninterested in the arts or the humanities. Well may he urge that we should regard training for a job or profession as only one incident in the educational process, and that the curriculum should be one in which ideas are discussed and the student taught how to discover the facts for himself.

While Dr. Green rightly argues that we must relate all forms of education to life in society, when it comes to ways and means he focuses his attention on what he terms the educationally under-privileged, and the view he takes of the functions of the Workers' Educational Association is correspondingly narrow. He would limit its activities to meeting the needs of the manual worker. In this he takes an even more restricted view than was taken by the working party under Mr. A. Creech Jones's chairmanship which recently reported on trade union education to the Workers' Educational Association. That report called for a more specific and concentrated effort by the Association to meet the needs of the trade union movement; but it showed also a real awareness of the implications of the situation to-day, and did not suggest a policy limited exclusively to meeting even the widest educational needs of that movement.

The two reports reach similar conclusions regarding the measures which might be adopted to meet the limited demand, particularly by way of supplementing the tutors which the Workers' Educational Association draws from the universities. Useful as may be the experiments suggested, particularly in the effect on leadership in the trade unions, neither Dr. Green nor the working party pays attention to the wider aspect of the extra-mural activities of the universities. Only to a limited extent do they share the conception of adult education which Prof. R. D. Waller displays in his appreciation of H. Pilkington Turner: "Adult education", wrote Prof. Waller, "is what happens when knowledge is transmitted from mind to mind in such a way as to kindle a glow of love and hope and faith in life, and to confirm both those who give and those who receive in their sense of the dignity of human destiny and of their own responsibilities in the face of it".

Adult education in that sense is exactly what is needed to vitalize a democratic society to-day and to enable it to preserve its traditions and its free institutions. Broadcasting and television could help to encourage the receptivity on which such education proceeds; but they could equally, if misdirected, prove formidable obstacles to this enlargement by inspiration. This is not to deny that broadcasting has played an important part in raising the standard of public taste and understanding over the past twenty or thirty years; but that influence is due in large measure to the conception of public service which has dominated broadcasting policy. Only time can show whether the safeguards written into the Television Act will be adequate to ensure that the influence of television on standards is beneficial and that its educational possibilities are fully utilized.

Even if it is only to encourage the background of interest against which adult education proceeds most effectively, the importance of broadcasting and television is not to be under-rated. It is difficult to accept Prof. Robert Peers's statement that the most serious obstacle to the rapid development of science courses in adult education is the absence of any general interest in science. It may be true that the demand for science courses in extra-mural education is not advancing as briskly as might have been expected; but there is abundant evidence of a widespread interest in science which finds expression, for example, in the activities of amateur scientists in many ways. Such activities may not lead to any understanding of science as a whole and its implications; but they testify to an interest which in adult education could and should lead to such understanding, if teachers or tutors are available.

The supply of teachers is most probably the critical factor, and perhaps all the more if in future we are to look to the day-release class rather than to the traditional evening class as a vehicle of adult education. Scientists are showing themselves increasingly aware of the importance of explaining themselves. Though there are defects in scientific

education in Britain to be overcome—and especially a tendency to segregate scientists—the danger is now more generally appreciated, and it is noteworthy that all proposals for the expansion of technological education seek to minimize that danger.

Scientists are already co-operating in extra-mural activities, and for all who possess some capacity for interpretation and exposition to participate, either formally in extra-mural activities, through their professional associations or in private in such ways as are open to them, this task of assisting in the public understanding of science and its implications is one of the most important ways in which they can to-day discharge their obligations as citizens. The extent to which they respond to this need and take part in the critical discussion of proposals designed to alleviate the immediate shortage of science teachers, and assist in the most effective use of the resources at our disposal for teaching science and technology generally, will largely determine the ability of democratic institutions to adapt themselves to the needs of to-day, and to throw up leaders capable of formulating the policy required to preserve those institutions and their traditions. Whatever changes may be necessary in the nature of adult education, any limitation or segregation of students to particular social classes or industries would be deplorable.

Objective teaching cannot take place in the context of class prejudice, and the bringing together of a wide range of social strata, of men and women of varied experience and outlook, is a prerequisite if adult education is to make its full contribution to that balanced outlook and public understanding on which the continued functioning of free and democratic institutions so largely depends. It may at least be hoped that when the Minister of Education receives the report of Dr. Eric Ashby's committee on the finance and administration of adult education, she will be able to announce a policy that will do more than remove the uncertainties which, as the last report of the Universities' Council for Adult Education shows, have hindered work in this field for the past eighteen months or more. Not only is a policy required which will permit development to be planned with confidence while giving the necessary flexibility for vitality and wealth of experiment; it should equally encourage that type of adult education to which the Prime Minister referred in his message last year to the General Council of the Trades Union Congress: "The mental and moral outlook of free men studying the past with free minds in order to discern the future demands the highest measures which our hard-pressed finances can sustain". If it is also true that, as Sir Winston continued, the appetite of adults to be shown the foundations and processes of thought will never be denied by a British administration cherishing the continuity of our island life, it is no less true that the continuity of effective administration and of free institutions may well depend on the extent to which public understanding is fostered in exactly that way.

BIOCHEMISTRY OF GENETICS

The Biochemistry of Genetics

By Prof. J. B. S. Haldane. Pp. 144. (London: George Allen and Unwin, Ltd., 1954.) 15*s*. net.

THIS book, by Prof. J. B. S. Haldane, is, as one has come to expect, a remarkable, a stimulating, and yet a motley work. The brief volume is an outgrowth of a series of lectures delivered to the Department of Biochemistry, University College, London, in 1950 and 1952, and is thus directed primarily towards biochemists. The contents, however, may well prove even more stimulating to geneticists.

Haldane discusses primarily the action of genetic material, described in biochemical terms as deduced from studies on viruses, bacteria, fungi, higher plants and animals. He describes in brief terms the genetic control of biochemical reactions in bacteria and fungi, of pigment formation in higher plants and animals, of antigen formation, and the genetics and biochemistry of a variety of inborn metabolic errors in man. Thus the book is remarkable for the great diversity of material considered from a common point of view, and so bears testimony to the extraordinary wide reading and interests of the author. It is, in fact, this breadth of material as well as the point of view of the author which makes the book stimulating reading.

The brevity of the treatment of such a diverse field leads of necessity to a somewhat superficial consideration, as well as to a great deal of unevenness in the material covered. Furthermore, in considering fields in which he himself has not worked, Haldane's choice of material is rather selective. The book also contains numerous errors of fact. Thus, this work should not be used as a reliable source of information, but is rather a delightful essay on the genetics of biochemistry.

One cannot read this volume without deriving pleasure from certain sallies of the author, and taking exception to others. Thus Haldane's observation of the lack of appreciation by the "American School" of the origin of the postulate that genes make enzymes is a happy one and perhaps justified. On the other hand, when considering the Neurospora work of the "American School" he comments: "It is moreover possible that more is known than has been published. Some of the workers concerned are now paid by the Atomic Energy Commission and such an affiliation at best imposes a delay on publication, at worst holds it up indefinitely". It may well be true that more is known than has been published; but if so, as far as this reviewer knows, it is for human rather than political reasons. While it is true that a great deal of research on microbial genetics is supported by the United States Atomic Energy Commission, this support has facilitated research and has neither suppressed nor delayed publication in this unrestricted field. Haldane's book also has many political quips concerned with the Lysenko controversy. These lose a great deal, however, as Haldane poses the problem primarily on the basis of whether Lysenko is right or wrong, where it would appear to many that the controversy is on an entirely different level, namely, does Lysenko make use of truly objective scientific methods? This obscurantism again does not seriously detract from the book as a whole, since it consists primarily of asides and thus does not enter into the mainstream of the problems under consideration.

In reading the book as an essay, one derives great pleasure and stimulation, a great deal of which comes

from the breadth of knowledge and interests of the author. The conclusions concerning the nature of gene action are refreshingly different. Haldane feels that biochemical genetics is approaching a critical epoch, a time one may well be able to specify what a given unit of genetic material is doing. With this most geneticists will agree. He feels, however, that this knowledge will stem from a study of 'vitaminless' mutants rather than 'amino acidless' mutants, as he feels the action of gene-controlling vitamin synthesis may well be direct, while the genetic control of amino-acid synthesis must be indirect. The evidence for such a difference in the action of genetic material is scant indeed, and, in the opinion of this reviewer, based on studies not referred to by Haldane, this difference is improbable. The discussion of problems of this nature makes, however, for pleasant speculation. Lastly, Haldane concludes that genes need not act by a direct replicating process, but rather that genetic material in its action and replication passes through a cycle involving intermediate states. Considerations of this sort have been given scant attention in recent years, and it is with pleasure that one reads and ponders these ideas, since the straws in the wind suggest that they will be the problems of the future.

DAVID M. BONNER

STRESS WAVES IN SOLIDS

Stress Waves in Solids

By H. Kolsky. (Monographs on the Physics and Chemistry of Materials.) Pp. x+212+3 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1953.) 25*s*. net.

STRESS propagation in solids has recently become the object of a remarkable revival of interest. This is partly due to the recent development of electronic apparatus capable of generating and detecting stress pulses; for, without this, experimental work was a matter of considerable difficulty. Further, the study of stress pulses of large amplitude is obviously of military importance, and the Second World War not only focused attention upon elastic waves but also led to the initiation of plastic wave theory. However, those who are interested in stress waves have been handicapped by the lack of a reference book on the subject and by the state of the literature, which has become scattered in journals of engineering, physics, seismology, acoustics and mathematics. In writing this monograph, the author has materially improved the situation.

The book is divided into two parts and, of these, the first is concerned with elastic waves. The introduction to this subject is very clear and includes a brief treatment of æolotropic media. The theory of the extended isotropic solid is dealt with in detail, and some of the effects which are associated with boundaries are discussed; these include the two-dimensional problems of Rayleigh waves, reflexion and refraction. A chapter on propagation in bounded solids includes an outline of the various engineering theories of thin rods together with the 'exact' Pochhammer treatment of cylinders and a discussion of the ways in which the former approximate to the latter. The rest of this part of the book deals with experimental investigations, and mention is made of the well-known pressure-bar experiments of B. Hopkinson and of R. M. Davies. Some recent work on ultrasonics is summarized very briefly.

In the second part of his book, the author deals with stress waves in imperfectly elastic media; this is particularly welcome. It starts with a treatment of internal friction and stress propagation in visco-elastic solids. A chapter is devoted to the experimental determination of dynamic elastic properties and includes a discussion of results. A very interesting treatment is given of plastic and shock waves in solids, which includes the theories of G. I. Taylor, Th. von Kármán and K. A. Rakhmatulin for the infinite wire. In the last chapter, the author deals with the important subject of fractures produced by stress waves; he mentions the work of J. Hopkinson and of B. Hopkinson and describes the very illuminating experiments which he and his associates have made and which will surely become very well known.

The list of references indicates that the work is intended chiefly for the physicist; while it is excellent for this purpose, the engineer will find this list inadequate in some respects. The book is written lucidly and the mathematics is simple. Thus, the elasticity equations are presented in component form in the manner of Timoshenko, and the use of vectors is reserved as the subject of an appendix. There can be no doubt that this book will be widely read. It is excellently written and is a valuable contribution.

R. E. D. BISHOP

MKS UNITS

The M.K.S. System of Units

A Guide for Electrical Engineers. By T. McGreevy. Pp. xii+283. (London: Sir Isaac Pitman and Sons, Ltd., 1953.) 21*s*. net.

IN Britain, general interest in the MKS system of electrical units really began some four years ago with the publication by the Institution of Electrical Engineers of a symposium of papers on the subject. Since that time, the rationalized MKS system has gained considerable popularity with teachers, quite apart from its adoption in technical practice, and several short explanations of it have been published. Mr. T. McGreevy's book is considerably fuller than any of these, and is written both for the engineer who is concerned with using the system, and the teacher of electrical engineering for whom it offers new approaches to the subject. It will interest also teachers of physics, for the author discusses the fundamental principles of measurement in some detail.

The œrsted, gauss and maxwell always seemed to have a firm co-opted status as practical units, and it may be harder for the engineer to learn to think habitually in amperes per metre and volt-seconds than it is simply to accept the change of units. Here the book should be most helpful. The author derives many of the chief results in motor, generator and transformer theory from first principles, gives some worked examples on the properties of magnetic materials, and has tabulated formulæ and conversion factors for reference.

The earlier chapters are directed chiefly to teachers in technical colleges. A scheme for introductory classes at two different standards is outlined, in simple terms for part-time students and in a more analytical form for full-time students. With the ampere established as the fourth fundamental unit, the definitions of H as the line integral of I and of B in terms of a flux-cutting e.m.f. are logical first

steps in electromagnetism. The ballistic galvanometer is used in the earliest stages, and no objection to using an instrument before its full theory is taught can fairly be made by teachers whose own study of electricity was probably initiated with the leaf electroscope. The treatment at both levels is convincing (though at one stage an imaginary experiment is invoked), and should be readily understood by students, which is its justification. In developing an introductory treatment, the teacher is rather in the same difficulty as the centipede; concern for logical sequence will not necessarily make things run more smoothly. The basis for accepting the Biot–Savart law and the first circuital theorem is the experimental work of Ampère; but a purely deductive approach on these lines would be too severe. Again, a rigid deductive presentation founded on Coulomb's law is within the grasp of accomplished mathematicians; but no beginner could ever understand it. Mr. McGreevy asks the student to accept the first circuital theorem and the concept of magnetomotive force with the help of rough quantitative experiments, and after this the path is clear and easy to follow.

The book is to be recommended, and should meet a need which has been felt for some time. It should also stimulate much thought and discussion about elementary teaching methods. G. R. Noakes

PROF. MEGHNAD SAHA: SIXTIETH BIRTHDAY TRIBUTE

Professor Meghnad Saha

His Life, Work and Philosophy. Edited by S. N. Sen. Pp. viii+176+19 plates. (Calcutta: Meghnad Saha Sixtieth Birthday Committee, Indian Association for the Cultivation of Science, 1954.) 5 rupees; 10*s.*; 1.50 dollars.

THIS account of Prof. Meghnad Saha's scientific and political career has been issued as a tribute to him in celebration of his sixtieth birthday by a committee under the chairmanship of Prof. D. S. Kothari. It emphasizes, rightly, Prof. Saha's pioneer work on thermal ionization and selective radiation pressure which established his position in the world of astrophysics more than thirty years ago and led to his election to the Royal Society. But his heart was in physics, and it was only after a considerable output of papers on purely spectroscopic problems and nuclear physics that he returned to the solar corona as a subject of study. Active interest in the propagation of electromagnetic waves in the ionosphere led later, with the development of radio-astronomy, to further work on radio-waves escaping from the sun and stars.

Meanwhile, Prof. Saha had been living a very active and successful life as a professor of physics at Allahabad and Calcutta, building up research schools in ionospheric studies and nuclear physics. He had become an active member and leader in the development of scientific societies and other activities in India. The Indian Science Congress, the United Provinces Academy of Sciences (later the National Academy of Sciences, India), the Indian Association for the Cultivation of Science and the National Institute of Science, all in turn elected him as president. Prof. Saha was also mainly instrumental in the formation in Calcutta of an Institute of Nuclear Physics for training personnel and carrying out fundamental research. He was appointed honorary director of the Institute. He was also a member of the Board, later the Council, of Scientific and Industrial Research. Through many articles, signed and unsigned, in *Science and Culture*, Prof. Saha published his views on science and its social relations.

In 1951 Prof. Saha stood for Parliament as an independent member and was elected by a large majority. In his work as a member of Parliament he has been concerned with education, industrialization, river valley projects and national planning. Throughout his life he has been a fighter for causes which he felt to be right, and it is largely due to his forthright spirit that he has risen from a humble beginning to the position of leadership that he holds to-day in the world of Indian science.

F. J. M. Stratton

FOSSIL BOTANY

An Introduction to the Study of Fossil Plants

By Prof. John Walton. Second edition. Pp. x+201. (London: Adam and Charles Black, 1953.) 30*s.* net.

THERE have been many notable advances in the field of palæobotany since the first edition of this useful text-book was published in 1940; the problem in preparing the second edition has been to make a limited selection of these for inclusion, and this the author has done chiefly from among the pteridophytes and pteridosperms of the late Palæozoic. For example, as further illustration of significant phases in the evolution of some of the chief groups of vascular plants, substantial information is included about the structure of the Lower Carboniferous horsetail cone *Protocalamostachys*, in particular of its sporangiophore; about the structure of various Carboniferous seeds, especially *Calathospermum* and *Salpingostoma* from the Scottish Calciferous Sandstone Series; and about the demonstration of heterospory in the Carboniferous fern *Stauropteris*. Space has also been found to add a brief discussion of such recent critical studies of more modern seed plants as Simpson's stratigraphical use of Tertiary pollen floras from Mull and Ardnamurchan, and Elias's work on grass fruits in studies of the evolution of the grasslands of North America during the Miocene and Pliocene—the latter of particular palæontological interest in its relationship to the evolution of the horse.

The opportunity has also been taken to revise some of the useful tables of stratigraphic correlations, and of age of geological periods, to bring them into conformity with more modern data; and the final chapter on climate and world floras has been amplified, with a broader discussion of evolutionary aspects and including such a recent theory as Hoyle's astrophysical explanation of the former occurrence of tropical floras at high latitudes.

When so many sections of the book have thus been brought up to date within the limits of the publication, it is indeed to be regretted that space could not have been found to revise the chapters on the Cordaitales, Coniferales and Cycadales; for in these groups some of the most significant of the recent additions to palæobotanical knowledge have been made through the work of Florin, Harris and others. It is to be hoped that in any future edition the account of these groups may be amplified, for the existing text-books on gymnosperms are notoriously out of date in this respect.

MYXOMATOSIS IN BRITAIN

By Dr. C. H. ANDREWES, F.R.S.
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THE deliberate introduction into Australia of myxomatosis or rabbit-plague has undoubtedly brought immense economic benefit to that country. Rabbits are a pest in Britain also, and myxomatosis has now reached these islands. Are we to expect wholesale destruction of our own wild rabbit population and corresponding economic gain? The answer to these questions is not easy, for myxomatosis seems to be behaving very differently in South America, which is its native land, in Australia, in France and in Britain.

In South America the virus of myxomatosis infects the native rabbit or tapeti (*Sylvilagus brasiliensis*), causing a non-fatal disease and being carried by mosquitoes (*Aedes* spp.). Its existence became known when, in 1898, it infected Sanarelli's laboratory rabbits in Montevideo and almost wiped them out. Domestic rabbits are derived from wild European rabbits, *Oryctolagus cuniculus*, and, in them, in contrast to the tapetis, myxomatosis is almost uniformly fatal. Accordingly, Aragão[1] suggested that the virus could be used for exterminating wild European rabbits where these were a pest, as they decidedly are, especially in Australia.

Early attempts to follow up this idea in Australia, Britain and Scandinavia attained only limited success: the disease obtained no permanent foothold. In 1950 further attempts were made in Australia to use the infection for destroying wild rabbits. Six of seven liberations apparently came to nought; but the seventh, just when it was thought to have failed likewise, suddenly flared up over unexpectedly wide areas. Probably it was spread by mosquitoes. Since 1950 myxomatosis has spread over much of south-eastern Australia, where it is estimated to have killed four-fifths of the rabbits in 1952–53 and to have increased rural production by £50,000,000.

In 1952 a French doctor introduced the infection into his estate south of Paris. He succeeded in his object of killing off his wild rabbits; but the disease did more: it spread beyond his park and in less than two years it had covered most of France and has now reached the north of Scotland. Why the disease has been spreading so widely when previous attempts to introduce it failed, we do not know. In France, the disease was by no means generally regarded as a blessing. Possibly the economic gains were on balance greater than the losses. But the disease affected not only wild rabbits but also the tame ones in rabbitries, which are of much economic value; and the *petits chasseurs* were very vocal because their week-end sport was spoilt.

Myxomatosis reached Britain about September 1953—how, we do not know. It could have been deliberately introduced by man, carried in infected mosquitoes or in rabbit fleas which had become accidental passengers on birds. The occurrence of the early outbreaks in counties facing the Channel—Kent, Sussex and Essex—suggests a natural method of spread rather than an intentional introduction. In view of the early failures to spread the disease, it seemed likely that the disease might die out during the winter months. On the contrary, it smouldered in its original foci and new centres of infection were reported nearly every week in south-east England.

Late in 1953 an advisory committee was appointed by the Minister of Agriculture and Fisheries and the Secretary of State for Scotland. Its first decision was to approve the attempts made by the Ministry to 'contain' the early outbreaks, to give time for the whole position to be assessed. But the virus was not to be contained; it spread despite man's efforts and with increasing momentum as summer followed spring[2]. There is no doubt that when farmers began to realize that they had much to gain from destruction of rabbits, they obtained infected animals and released them on their own properties. The bigger 'jumps' of infection in the early summer of 1954 can be traced to such introductions.

The official attitude hitherto has been to take no part in, and in fact to deprecate, intentional spreading of the disease. A major reason for this concerns an aspect of the disease not yet discussed: the disease is a very unpleasant one. Infected rabbits are of a revolting aspect; their eyelids are so swollen that their eyes are closed; their faces, the bases of their ears and often their genitalia are swollen. When they are ill they come into the open and sit about, breathing slowly and often with difficulty, for several days before they die. Letters to newspapers reporting that they are "in agony" and attempting suicide need not be literally believed; nevertheless there is a very powerful and vocal humanitarian argument against spreading the infection in order to obtain economic rewards.

In order to foretell the likely future of myxomatosis in Britain, we need to know more of its method of spread and the controlling factors here and elsewhere. Thus we can better judge whether its activity in Britain should be helped or hindered.

Method of Spread

The natural disease in South America is apparently mosquito-borne. So, too, in Australia, mosquitoes seem to play a major part. They and other biting insects seem to act only as mechanical transmitters of infection—'flying pins'. In its first year there, the killing of rabbits was mostly along river-beds only, *Culex annulirostris* being the main vector. But in 1951–52 spread occurred far away from rivers, *Anopheles annulipes*, a wide-ranging mosquito, being largely concerned[3]; this species is believed to feed on rabbits in warrens underground. The seasonal incidence and character of outbreaks in Australia are quite closely linked with rainfall and associated prevalence of different biting insects.

There is little exact information as to the method of spread of myxomatosis in France. The rapidity of spread and the frequency of attack on tame rabbits suggest that a flying insect, probably a mosquito, plays a major part.

In Britain there has been no evidence of dramatic 'jumping' of infection, as in Australia, except where man has intervened. It is thus interesting that there is, as yet, no evidence that mosquitoes are playing any major part in spreading the disease in this

country[4]. The fact that there is widespread infection in wild rabbits but only a few authentic infections of tame rabbits is also evidence against participation of a winged vector. On the other hand, rabbit fleas (*Spilopsyllus cuniculi*), which do not occur in Australia, may well be acting as a vector here. I have found, as have others, that among rabbits kept free from ectoparasites, cage-to-cage infection in the laboratory has not occurred. Fleas are abundant on wild rabbits and with warmer weather congregate more on the head where myxomatous lesions chiefly occur. Though specific parasites of rabbits, they are occasionally carried on birds and presumably could in this way help in wider spread of infection[5].

Changes in Rabbit-virus Relationship

A relationship in which a parasite kills more than 99 per cent of its hosts is not likely to be stable. In associations of long standing, host and parasite become adapted to living together, as is the case with myxoma virus and the South American tapeti. An adjustment in this sense is sure to take place elsewhere. Development of inherited resistance is likely to take a long time in rabbits—even they are slowly breeding beings in comparison with a virus. There is so far little evidence that offspring of recovered rabbits are resistant. On the other hand, there have been found in Australia virus strains of lowered virulence, taking longer to kill and killing only 90 per cent instead of more than 99 per cent. Rabbits living longer remain infectious longer and the virus can therefore spread more readily, so that one with a tendency to kill more slowly has an evolutionary advantage[6]. So far there is little or no evidence of emergence of an attenuated virus in Britain, or, so far as one knows, in Europe. Indeed, the apparently more stable European strain is being used for re-introductions of virus into Australia.

Human Intervention and Myxomatosis

In Australia, even where the kill of rabbits is very high, the disease passes on, and surviving rabbits begin to breed. The new generation of rabbits will not be immune and to keep them down and, as the Australians say, to "back up the virus", other destructive measures are being used and, when needful, virus is re-introduced. Thus, myxomatosis is greatly helping Australian economy; but to take full advantage of it, scientific "backing-up" is being used on a very large scale.

In the British Isles, myxomatosis has now reached nearly every county of England and Wales and a number in Scotland and Ireland. Its incidence, however, is very patchy. In most counties one can walk for miles and see plenty of healthy rabbits and not a single diseased one. The total destruction of rabbits must be still trivial. The poor summer of 1954 may have militated against spread by 'flying pins', and a warm September might yet alter the picture. It seems likely, however, that myxomatosis, except perhaps in south-east England, is only here and there. Things might remain like this into the indefinite future, with the disease spreading naturally or otherwise from farm to farm, parish to parish and back to its starting point as new susceptible rabbits grow up. There might well be no striking effect on rabbit numbers, except indirectly as the existence of the disease affected the trapping industry and the taste of the people for rabbit-meat; these factors might leave us in many areas with more rabbits rather than less. Further, we should still have the disease with us, with local epidemics killing the rabbits in hundreds in its highly unpleasant fashion. If such should indeed be the outcome, we should have all the disadvantages of myxomatosis with no compensating economic gain. It might then be cogently argued that we should follow the Australian example, introduce the disease simultaneously into areas of convenient size and "back it up" intensively. The rabbit population might thus be drastically reduced with a resultant gain not only to our economy but also to our very natural wish to inflict the least possible suffering on the rabbits. Maximum suffering over a long period would be caused if the disease kept going spontaneously round the country like a travelling circus. Scientists did not introduce the disease into Britain, and no official or unofficial action of man can possibly stop it. What the disease will accomplish 'on its own' we cannot yet foresee.

[1] Aragão, H. de B., *Memorias do Ist. Oswaldo Cruz*, **20**, 225 (1928).
[2] Report of Advisory Committee on Myxomatosis (H.M. Stationery Office, 1954).
[3] Ratcliffe, F. N., Myers, K., Fennessy, B. V., and Calaby, J. H., *Nature*, **170**, 7 (1952).
[4] Muirhead Thomson, R. C. (personal communication).
[5] Rothschild, M. (personal communication).
[6] Fenner, F., *Nature*, **172**, 228 (1953).

NUCLEAR AND MESON PHYSICS

INTERNATIONAL CONFERENCE IN GLASGOW

THE International Union of Pure and Applied Physics and the United Nations Educational, Scientific and Cultural Organization sponsored a conference on nuclear and meson physics which was held in the Department of Natural Philosophy, University of Glasgow, during July 13–17, under the general chairmanship of Prof. P. I. Dee. A wide range of topics was covered, and more than one hundred papers were presented. In these circumstances it is impossible, in a short review, to do justice to, or even mention, all the contributions.

The opening session was on nuclear forces and nucleon scattering. The present state of knowledge in this field was surveyed by Prof. H. S. W. Massey, who stressed the need for more work on the very light nuclei, in addition to that on proton–proton and proton–neutron scattering, to try to gain some direct evidence on the presence or absence of many-body forces. The recent work on nucleon–nucleon scattering at Harvard and Brookhaven was described by Prof. N. F. Ramsey; the extension of proton–proton scattering experiments to high energy has shown that the apparent constancy of the total cross-section at high energies is due to a broad flat minimum in the range 200–400 MeV.

In the angular distribution of proton–deuteron scattering at 20·6 MeV., described by Dr. D. O. Caldwell, a minimum at small angles has been found, due to the interference between the Coulomb and nuclear scattering. This interference should enable data to be fitted with a unique set of phase shifts and decide between the two sets which both fit the earlier data. Work was also reported from several laboratories on the scattering of polarized nucleon beams.

An account of the present status of the meson theory of nuclear forces by M. M. Levy and R. E.

Marshak was presented by Prof. Marshak, who emphasized the different approximations used in current treatments. He made it clear that, although the present theory includes many of the observed features of nuclear forces, further developments towards a fully non-static approximation are required.

The sessions on nuclear data and nuclear models was opened with review papers: by Prof. J. A. Wheeler on nuclear models, and by Prof. S. Devons on the experimental determination of energy-levels. Prof. Wheeler dealt with the work currently in progress on different aspects of the problem and, in particular, described the work of K. A. Brueckner. This considers a test nucleon passing through an infinite nuclear medium. The wave describing the nucleon is scattered by each of the moving centres in the medium, the forward-scattering amplitudes adding coherently to the primary wave. No elementary law of interaction enters the calculations—only the phase shifts which describe the nucleon–nucleon scattering up to 100 MeV. The present experimental information, however, is not sufficiently complete to exploit this approach.

Prof. Devons emphasized the great theoretical and experimental advances of the past few years, and pointed out that in some cases theory has now outstripped experiment. He instanced the small differences in the Coulomb energy for corresponding levels of a T-multiplet (which have considerable interest, but are not always known with great accuracy) and the low-lying rotational levels of some heavy nuclei which need to be determined with the highest precision. Of great interest was his description of the measurement at the Imperial College of Science and Technology, London, of the reduction of the Doppler shift as a recoil particle passes through slowing-down materials. This method promises to fill the gap in the lifetime measurements of radiative transitions. Of the numerous interesting experimental papers read at this session, that of Dr. W. W. Buechner describing the work at the Massachusetts Institute of Technology, using a magnetic spectrograph as a particle analyser, most emphasized the great accuracy attainable with present-day techniques. A theoretical paper of particular significance was that of J. P. Elliot and B. H. Flowers, who derived the even parity, low-lying levels of mass-19 nuclei. These are assumed to arise from configurations of the form $\Sigma_z d^{n-z} s^z$ (x = 1, 2 or 3). By using essentially only one free parameter, the positions and spins of these levels are predicted and show good agreement with the somewhat sparse experimental data. Prof. V. F. Weisskopf closed these sessions with a stimulating and provocative summary of the present position. The problems he discussed included that of the effective mass of a nucleon inside the nucleus, and the possibility of the internucleon forces in nuclei being different from those between free nucleons.

Another aspect of low-energy nuclear physics was discussed at the session on photo-disintegration. The results of Dr. H. W. Koch on X-ray scattering were interpreted by Dr. U. Fano as showing that the giant resonance does not possess a detailed structure. A tentative theory of the giant resonances was put forward by Dr. D. H. Wilkinson. This explains the resonances in terms of single-particle transitions for the absorption process, and the anomalously large yield of high-energy particles and their angular distribution are predicted in terms of the same absorption process.

The field of beta- and gamma-ray transitions was surveyed by Dr. K. Siegbahn, who described the recent developments which enable extremely accurate measurements to be made. A most stimulating talk on the interaction in β-decay was given by Dr. C. S. Wu. The Fermi and Gamow–Teller components have approximately the same magnitude, and recoil experiments on helium-6 show that the latter is a tensor interaction. Preliminary results on neon-19 recoils suggest that the Fermi interaction is scalar, as favoured by other evidence. The more recent calculations which nullify the necessity for the pseudoscalar component have been confirmed in their conclusion by the direct measurement of the spin of radium E by K. Smith, who has obtained a value of 1.

The conference was divided into two halves: during the first two days nuclear phenomena not involving π-mesons directly were discussed, and the last two were mainly devoted to mesonic (largely π-mesonic) physics. The intervening day, July 15, was spent in a chartered steamer sailing among some of the lochs and islands of the Firth of Clyde; this not only allowed a view of some beautiful scenery, but also gave the delegates an opportunity for discussion, particularly valuable by reason of the rather tight programme.

Prof. H. A. Bethe opened the morning session on July 16 with a general survey of pion–nucleon interactions. He discussed the cross-sections for pion–proton scattering up to about 200 MeV. which are interpretable in terms of phase shifts for angular momentum states $P_{3/2}$, $P_{1/2}$ or $S_{1/2}$ and states of total isotopic spin $T = {}^3/_2$ or $T = {}^1/_2$. Of the three possible analyses into phase shifts, only one gives a resonance in the $P_{3/2}$ $T = {}^3/_2$ state, but physical reasons are given for this being the most plausible analysis. These results, including the low-energy P-wave scattering, are interpreted in terms of the pseudoscalar coupling theory of mesons to nucleons, using Tamm–Dancoff approximate methods. The more difficult interpretation of the photo-production cross-sections was also discussed. In this session, papers on experimental researches on pion–nucleon scattering and pion production up to energies of 1·5 BeV. were presented by Dr. R. H. Hildebrand (Chicago), Dr. J. Ashkin (Carnegie Institute of Technology), Dr. J. B. Platt (Rochester, N.Y.) and Dr. A. C. Helmholtz (Berkeley).

In a session on detailed meson theory, Prof. F. J. Dyson gave an account of the surmounting of difficulties, in the Tamm–Dancoff method, at Cornell. Other papers included two on the origin of spin orbit coupling in nuclei, while Dr. M. Cini reported the application of the variational method of Cini and Fubini to pion–nucleon scattering. This latter method gives a correct fit of the P-wave, though not the S-wave, phase shifts to the 'Glicksman set' of phase shifts, and seems capable of refinement by, for example, the introduction of a further variational parameter.

The afternoon of July 16 consisted of four simultaneous meetings of special interest. These were on β and γ transitions and mesic X-rays, detailed theory of nuclear models, field theory and photodisintegration (mentioned earlier).

Dr. J. Ashkin reported on measurements of the intensities and energies of X-rays from π-mesic atoms. Energy measurements of X-rays from transitions between outer shells, where the π^--meson nucleon interaction does not appear, gives a close determina-

tion of the π^- mass, while measurements of line shifts in inner shells where the nuclear interaction operates can be related to phase shifts in the meson–nucleon scattering. Dr. J. B. Platt reported work on the relative intensities of X-ray lines in order to find the attenuation resulting from nuclear capture from inner shells.

The field theory meeting was opened with a talk by Prof. W. Heisenberg on "Quantization of Non-linear Wave Equations"; it is proposed to introduce just one wave function for all matter, obeying a non-linear field equation. The equation

$$\gamma_\nu \frac{\partial \psi}{\partial x_\nu} + l^2 \psi(\psi^+ \psi) = 0$$

is taken as an example, and study of the likely commutation rules leads to the conclusion that the laws of quantum mechanics would be modified in a certain region of Hilbert space.

The conference ended on the afternoon of July 17 with a full meeting of all delegates, at which papers on heavy mesons and hyperons were presented. Dr. C. C. Butler opened the session with an excellent review of our present knowledge of heavy mesons and hyperons, and the conference closed on a high note with a paper by Drs. A. Pais and M. Gell-Mann on some theoretical speculations concerning the heavy particles, which included an interpretation of Λ^0 particles as particles of high intrinsic spin. The full proceedings of the conference will be published by the Pergamon Press.

E. H. Bellamy
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SCIENCE, ANIMALS AND HUMANITY*

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IF I were a psychologist I might understand, and even be able to explain, why animals, and in particular certain animals, evoke an emotional response in human beings, so strong in some that it is beyond the reach of reason. We all know of the cat lovers who carry their devotion outside the limits of economy or hygiene; of the dogs who lay undisputed claim to the best armchair or the master's place on the hearth-rug; of the horses, canaries and other animals who receive more consideration from their owners than persons more nearly related zoologically and therefore having, one would think, better claims to affection. On the other hand, by taking some animals into domestication, or keeping others in captivity, man accepts an obligation to look after them, for they are entirely dependent on man for the necessities of their being. It makes it easier for us to do our duty towards our animals if we are fond of them.

Emotion, then, is bound to creep into any discussion of relations between animals and man, and it is a deep and often disturbing emotion. To ignore it is unrealistic, and to be ashamed of it unnecessary; but it should not be allowed to cloud our reason, any more than any other emotion. Such undisciplined feeling is often associated with a morbid preoccupation with brutality—a revealing word—in books and articles, on the cinema screen, in conversation and perhaps in real life, and the minutiæ of violence excite a thrill of disgust, guilty pleasure or any other emotion; but above all a thrill. There can be few normal people who are totally unaffected by the sight or image of injury, be it accidental, criminal or surgical; but in most of us that basic attraction-repulsion is clothed in reason or rationalization. So in a discussion of animals let us try to recognize the shadow of the brute within our souls and keep him chained, and let us be especially wary lest any moralizing we may indulge in be the brute tugging at his leash.

There exists a great gulf between those whose primary interest is in the welfare of animals, and the scientists who use animals in their work. It is a gulf of misunderstanding so wide that the leaders in each field are often not on speaking terms with one another, at least in public. "Callous torturer", says the humanitarian, and the scientist replies "sentimental crank". Yet the first may be a reasonable, intelligent and responsible person, and the second as deeply moved by cruelty as any of his fellows, for whom the obligation of humanity is so obvious that he does not bother to explain it. But of course he should explain what he is about, and the layman who criticizes him should listen to the explanations.

What Dr. J. Bronowski says of the nuclear scientist[1] has a more general application. The scientist, he says, ". . . has one special responsibility . . . of enlightenment in scientific matters . . . the responsibility of knowledge, not of power . . . to illuminate for all men the choice which his work offers them. . . . Outside his laboratory, his task is to educate us in what goes on inside it, and to give it a meaning for us. In a world in which statesmen as much as voters are ignorant of the simplest implications in science, this is a formidable responsibility . . . [the scientist] has no other choice to-day but patiently to become a teacher, in a world in which distrust and prejudice are free. . . . There is no alternative to an informed public opinion: and that can exist only where scientists speak to voters, and voters accept their responsibility, which is to listen, to weigh, and then to make their own choice".

Now this is just the reverse of the point of view that I have heard from the lips of both scientists and administrators. Let us, they have said, keep quiet about animal experiments. People do not want to hear about them, and if we direct their attention to this side of scientific activity, it will merely give stamping-ground to the anti-vivisectionists. Or perhaps they will say, nobody bothers much about rats and mice and guinea pigs; but whatever you do, leave cats and dogs out of it; these animals to-day occupy the place in men's hearts that horses did a century ago, and we should let them lie sleeping. But is this playing fair with the voters?

We need not concern ourselves with the abolitionists who are unreservedly opposed to any sort of animal experimentation. It is possible to respect their feelings, but not their way of conducting controversy. Perhaps I may digress a little in order to show how careful one has to be in the matter of anti-vivisection propaganda. In 1948 a deputation of antivivisectionists met the Home Secretary, and cited a number of alleged cruelties. Referring to the work of Mellanby on experimental rickets[2] in puppies they quoted "animals were confined absolutely in kennels, 3 ft. 6 in. by 2 ft. 6 in., for 13 weeks. . . . These animals were most seriously attacked by

* Substance of a paper read on September 6, 1954, before Section D (Zoology) of the British Association meeting at Oxford.

mange". It seems a strange tactic to attempt to pillory work on rickets, which was at that time a major scourge, and which has now, as a result of that work, become a rarity. But on referring to the report itself we find that the purpose of prolonged confinement was to investigate the part played by exercise and confinement in the production of rickets, and that the animals so confined "grew well and kept in perfect condition". The animals attacked by mange were the subjects of an entirely separate experiment, and "because of the severity of the disease, the experiment was concluded".

The same deputation referred to some work done at Cambridge in 1931 by Florey and Webb[3], in which the effects of mustard oil on various tissues of the cat were examined. They said that the work was done under "a narcotic, chloralose", and that the experiments lasted from 3½ to 8½ hours. Now, the use of chloralose as an anæsthetic is limited to non-recovery experiments, and this fact is well known to scientists, but not apparently to their critics; and, although it was not specifically mentioned anywhere in the paper describing the experiments, the cats never felt any pain at all, for they were unconscious before the experiments started and never regained consciousness.

While the scientist's main job is to get on with his work, his opponents can spend all their time and resources on attacking him. Moreover, to answer ten words of accusation, however preposterous, may take a hundred words in reply.

Antivivisectionists have not yet succumbed to the advance of medical knowledge; but they are of no great consequence, although it is still possible for them to be a real nuisance. They should certainly not be allowed to inhibit scientists from expressing humanitarian views on animal experimentation. But what can one say when the Royal Society for the Prevention of Cruelty to Animals, the most influential body of organized animal welfare, whom we should all, I hope, wish to support and see prosper, asks "Why not endeavour to reduce the vast total of animal suffering in the laboratories? Until the animal experimental section of the scientific world shows some sign of concern in this direction, the R.S.P.C.A. would fail in its duty if it did not sound the drum of alarm"[4]. How have the scientists so come to neglect their duty of informing the public of what they are about that these questions can in all seriousness be asked?

Experiments on animals have led, and may be confidently expected in the future to lead, to great benefits to man and to animals, with all that that implies in the relief of suffering and the saving of life. The cost is the infliction of some pain on a number of animals that are neither consenting nor direct beneficiaries. Is this not, we are asked, "to do a little wrong" in order that one may be enabled "to do a great right"? Is it not the old argument of the end justifying the means?

Now these questions beg one assumption, that to inflict pain, in itself, is always wrong. But is it? Man, by entering into the arrangement of domestication, assumes the power of life and death over his animals. Civilized man also assumes the responsibility of avoiding cruelty to these same animals, and Great Britain has a good record in this respect. Pain is inseparable from life itself, and the occasional infliction of it from our dealings with each other and with our animals. But the infliction of pain is not synonymous with cruelty. The Shorter Oxford English Dictionary defines cruelty as "a disposition to inflict suffering: delight in or indifference to another's pain", and here is the real point. In the words of Lord Wright in the House of Lords on July 2, 1947, ". . . it is impossible to apply the word cruelty to efforts of the high-minded scientists who have devoted themselves to vivisection experiments for the purpose of alleviating human suffering . . ." Those who, for whatever motives, inflict pain on animals and are indifferent to the fact, are cruel, and deserve condemnation. But a word of caution is necessary here. Because a scientist, in reporting his work, does not explicitly state that he was aware of the pain he was inflicting, that he did it with reluctance and was careful to minimize it, it must not be assumed that this was not so. He has a right to be regarded as a humane person unless he gives evidence to the contrary. Moreover, as we have seen, scientific language is too often indigestible material for the layman, and technical descriptions of experimental procedures can make hair-raising reading for him. But in all the responsible examinations of alleged horrors perpetrated, in Great Britain at least, the scientist has been vindicated.

Scientists do not like being called callous blackguards, and, though individualists by training and inclination, they can show a surprising solidarity when unfairly calumnied. As Major Hume, of the Universities Federation for Animal Welfare, says, ". . . public opinion in scientific circles, which in the eighteen seventies befriended animals as a matter of course, has until recently been rendered allergic to any reference to the prevention of cruelty. Then animals enjoyed the open patronage of scientists as such, but subsequently they were largely deprived of it by the polemical intemperance of those who intended to act as their champions"[5]. One reads some personal feeling between these lines, for in some of its activities U.F.A.W. has not been immune from criticism by scientists, myself among them. But the point is well made. To-day we can state fearlessly what is generally accepted, that painful experiments should have a worth-while object and should be conducted with every effort to minimize the pain; and that pain beyond a certain level in severity or duration or a combination of both is never justifiable. To state such a principle requires that its observance be demonstrated, and this means bridging the gulf between scientists and animal protectionists.

Is the "total of animal suffering in laboratories" so "vast"? How are scientists to convince those who are open to conviction that this is a gross exaggeration? I think it very reasonable that laymen should want to satisfy themselves on this score, and understand why and how experiments, when they are painful—and most of them are not—are carried out. It is in fact one of the main functions of the Research Defence Society to explain, in language intelligible to the layman, what we all owe to animal experiments, and what safeguards exist against the unjustifiable exploitation of animals. Their journal contains some interesting accounts of the conquest of many diseases and deserves wider reading than it gets. But more, much more, needs to be done.

As a matter of fact, scientists themselves have anticipated the R.S.P.C.A. in showing "some sign of concern". As long ago as 1870 the British Association appointed a committee, which reported in 1871, "to consider the subject of Physiological Experimentation"[6]. The British Medical Association also turned

its attention to the controversy at about the same time, and reported in like vein. Earlier still, the giants of the biological world, men like Charles Darwin and Thomas Huxley, had expressed their concern about the possibilities of cruelty in laboratories. All this led directly to the Act of 1876, which controls painful experiments on animals in Great Britain, and was supported by most scientists. Under this Act, which has been and still is faithfully observed, all severely painful experiments are carried out while the animal is completely under the influence of an anæsthetic; if severe and enduring pain follows on recovery, life is destroyed forthwith. What more is wanted, if we are not to abandon the most fruitful method of medical research so far devised?

Prof. Robert B. Lawson, writing about animals in pædiatric research, says ". . . one cannot escape feeling the intense debt due the research animal. The way in which each type of investigation requires a particular animal is particularly striking. Rats play a key role in one study—mice in another—and the dog in a third. Rarely can one take the place of the other. We are indebted to all research animals for the tremendous advances in medical science that have made this generation of children healthier, bigger, and with more promise, than ever before"[7]. In a recent symposium on the design of animal houses, the chairman, Dr. Parish, said, "It is a good thing that laboratory workers themselves wish to improve the living conditions of animals and thus repay the debt . . ." Indeed, the progress that has been made in recent years in the housing, feeding, care and management of laboratory animals is quite remarkable, and owes everything to the initiative of the scientists.

It is a symptom of the times to try to make scientists the scapegoats for that which disturbs the public conscience. They are not the high priests of a secret cult, dealing in matters not to be revealed to ordinary men and women; neither are they mental acrobats and moral imbeciles. They are as good and as bad as the rest of the community, but no more indifferent to the sufferings of others than farmers or financiers.

If this tragic misunderstanding is to be got rid of, scientists must take time off to explain the mechanics and implications of their work and show that they respect the feelings, even the misgivings, of the humanitarians; and the public must modify its "Scientists—I'd like to drown the lot" attitude. An example of what mutual goodwill can achieve is to be seen in Vancouver, British Columbia, where, by friendly agreement on both sides, the local Society for Prevention of Cruelty to Animals supplies to the medical school unwanted, unclaimed animals, which would otherwise be destroyed. In a nine-point agreement, the conditions in which this surrender of unclaimed strays operates are laid down, and the medical faculty has been only too happy to abide by them. As a result of the agreement, the medical school gets the animals it must have, it allows the S.P.C.A. to visit its animal quarters, and indeed looks to that enlightened organization for advice and help in maintaining the best possible conditions for its animals. An atmosphere of co-operation exists which is a help, and a credit, to both sides.

It is worth examining this arrangement more closely. The animals supplied to the medical school may only be used for non-recovery experiments, that is, they are anæsthetized before use, and never recover consciousness; and they must be used within forty-eight hours of being handed over. All long-term experiments are done on animals obtained elsewhere.

Only dogs otherwise destined to be destroyed may be handed over, and these must not include any brought by their owners specifically for destruction, nor any bearing identification marks. The animals must be kept two days beyond the legal claiming holding period before being handed over. The S.P.C.A. inspectors may witness experiments and have access without appointment to records and to animal premises. No animal handed over by the S.P.C.A. ever suffers any pain at all; it has a painless death under anæsthesia. At the same time, the S.P.C.A. can and does satisfy itself that all the animals used are well cared for. This shows how far mutual trust and co-operation can go.

There can be no objection on humanitarian grounds to any animals, including cats and dogs, being used for non-recovery experiments. If objections are raised, they must be based either on an aversion to animal experiments on principle, whether or not they are painful; or on a profound mistrust of the scientist. The first alternative leads one into such a philosophical morass as few if any of us could escape from. I am inclined to think that the second alternative, mistrust of the scientist, is the real obstacle to co-operation. Sentiment comes into this question, and it is no use pretending we can keep sentiment out. It should not, however, be allowed to ride us. Scientists would prefer to obtain the animals essential to their work in ways which remove the danger of their being sold a stolen pup, and to have impartial people satisfy themselves about the propriety and humaneness of their work.

I would not like to leave the impression that to get scientists and humanitarians sitting around the conference table has, for the scientist, no more interest than to obtain more cats and dogs more easily. If that were one of the results, so much the better; but the issue is much larger.

To-day we have a duty to pursue medical research by all legitimate methods, and one of those methods is the use of animals. We also have a duty to be considerate in our dealings with animals, and the two duties are not incompatible. Can we not, like the British Columbians, explore the no-man's-land of misunderstanding and discover instead the common ground of humanity?

[1] *Observer*, May 9, 1954.
[2] M.R.C. Special Report No. 61 (1921).
[3] *Brit. J. Exp. Path.*, **12**, 286 (1951).
[4] *The Times*. Oct. 3, 1953.
[5] "UFAW Handbook on the Care and Management of Laboratory Animals", p. 2 (1947).
[6] Report of the British Association for the Advancement of Science, lxii (1870), and 144 (1871).
[7] *N.S.M.R. Bull.* (U.S.A.), **8**, No. 3, 4 (Jan–Feb., 1954).

OBITUARIES

Dr. Herman A. Spoehr

By the death on June 21 of Dr. Herman A. Spoehr, at the age of sixty-nine, plant physiology has lost one of its best known and most distinguished research workers and exponents.

Herman A. Spoehr was born in Chicago on June 18, 1885, and was educated at the University of Chicago, where he took his bachelor's degree in 1906. After working for a time in the laboratories of Emil Fischer in Berlin and L. Maquenne in Paris, he

returned to Chicago, where he worked with the well-known sugar chemist, J. U. Nef, and where he took the degree of Ph.D. in 1909. In the following year he joined the staff of the Carnegie Institution's Desert Laboratory in Tucson, Arizona, where he remained for ten years. During this period he published a number of papers which established his reputation as an original and critical investigator. Among his more important publications of this period may be mentioned those dealing with the mechanism of photosynthesis. At that time the theory that formaldehyde was an intermediate product in photosynthesis was very largely accepted. Spoehr, on repeating under properly controlled conditions the experiments which were supposed to provide the evidence for this theory, was unable to find the slightest indication of formaldehyde production, and Spoehr's work was no doubt largely responsible for the ultimate abandonment of that theory. Perhaps the most important of Spoehr's publications during his time at Tucson was his monograph "The Carbohydrate Economy of the Cacti", published by the Carnegie Institution in 1919.

In 1920 Spoehr moved to the Carnegie Institution's Coastal Laboratory at Carmel, California, followed in 1929 by a move to Stanford University, which in that year took over the housing of the Division (now the Department) of Plant Biology which had been created in the previous year with Dr. Spoehr as its first chairman. While at Carmel, among other publications, he produced two of particular importance. One of these, jointly with J. M. McGee, was "Studies in Plant Respiration and Photosynthesis", published by the Carnegie Institution in 1923, the other his well-known book on photosynthesis published in 1926.

For a short time in 1930–31 Dr. Spoehr was director of the Natural Sciences Division of the Rockefeller Foundation in New York; but in the latter year he returned to Stanford to resume the chairmanship of the Division of Plant Biology. He retired officially in 1950 but continued thereafter to work in the laboratory that he had directed for so long.

Throughout his life in the Division of Plant Biology Dr. Spoehr's main scientific interests continued to lie in photosynthesis and related matters. Particular mention may be made of his successfully bringing to maturity albino maize plants, while in later years he was much interested in the question of applying the results of research in photosynthesis to increasing the food supply of the world. This led to the idea of the culture of algae on a large scale for the use of food, and by 1947 the possibility of cultivating *Chlorella* on a large scale for this purpose was taken seriously and a preliminary analysis of the problems involved was prepared by Spoehr and H. A. Milner and published in the Carnegie Institution Year Book for 1948. Although preliminary work on the subject at Stanford Research Institution was ended in 1950, it has been continued elsewhere, and the recent (1953) Carnegie Institution Publication on "Algal Culture", edited by J. S. Burlew, indicates in no uncertain way that further investigation on the problem is proceeding vigorously.

During the Second World War the laboratory of which Dr. Spoehr had charge concentrated on the study of antibiotics from chlorophyll-containing organisms.

As well as by his direct contributions to plant physiological research and literature, Dr. Spoehr served the cause of science in other ways. He was a member of the board of directors of the Forest Genetics Research Foundation, a member of the scientific committee of the Board of Managers of the New York Botanical Garden, a trustee of the California Section of the American Chemical Society, a member of the executive board of the Save-the-Redwoods League and for a time chairman of the editorial board of Annual Reviews, Inc. He was a member of the American Philosophical Society, the American Academy of Arts and Sciences, an honorary member of the Linnean Society of London and the Deutsche botanischen Gesellschaft of Berlin. He was awarded the honorary degree of doctor of science of the University of Chicago and he received from the same University one of its Distinguished Alumni Awards in 1943.

Dr. Spoehr is survived by his widow, a son Dr. Alexander Spoehr, the anthropologist and director of the Bernice P. Bishop Museum in Honolulu, a daughter, his mother and a brother.

In preparing this notice of Dr. Spoehr I have been greatly helped by information provided by Dr. J. H. C. Smith and Dr. C. S. French, the present director of the Department of Plant Biology of the Carnegie Institution of Washington.

WALTER STILES

Dr. A. M. Turing, O.B.E., F.R.S.

ALAN TURING was born on June 23, 1912, and was educated at Sherborne and King's College, Cambridge. He was made a Fellow of King's in 1934; he submitted his fellowship dissertation—a version of the central limit theorem for the normal distribution—four months after being placed as Wrangler in the Mathematical Tripos. During his first years of research he worked on a number of subjects, including the theory of numbers and quantum mechanics, and started to build a machine for computing the Riemann ζ-function, cutting the gears for it himself. His interest in computing led him to consider just what sort of processes could be carried out by a machine: he described a 'universal' machine, which, when supplied with suitable instructions, would imitate the behaviour of any other; he was thus able to give a precise definition of 'computable', and to show that there are mathematical problems the solutions of which are not computable in this sense. The paper which contains these results is typical of Turing's methods: starting from first principles, and using concrete illustrations, he builds up a general and abstract argument. Many years later he used an elaboration of the same ideas to prove the unsolvability of the word problem in semi-groups with cancellation.

In 1936 he went to Princeton for two years; he worked on group theory and logic, receiving his Ph.D. for a dissertation on "Ordinal Logics". In this he showed that when transfinite induction is used in logic for proofs and definitions, it is not the ordinal up to which induction runs that has significance, but rather the particular way in which that ordinal is described.

He was awarded the O.B.E. for the work he did during the War, and after it he was invited by the National Physical Laboratory to direct the design of an electronic digital computor (which he christened "The Automatic Computing Engine"). Although the theoretical aspects of its design were his chief concern, he was also keenly interested in its electronics; and while the final construction was in progress

he turned to long-term problems, considering how machines might be made to learn by trial and error and the ways in which they could be compared with human brains.

In 1949 he was made deputy director of the Computing Laboratory at the University of Manchester, where work on an electronic computor had just started. He was elected Fellow of the Royal Society in 1951. His last work was a mathematical theory of morphogenesis; the main idea was to show how an originally uniform distribution of interacting substances may, as a result of diffusion, develop a strongly marked pattern. He had already published a version of the theory for distributions around a ring, and was at work on the case of a cylinder; using the machine to solve the appropriate differential equations, he was hoping to be able to exhibit the spiral patterns based on the Fibonacci series which are so frequently found in plants.

The marks of Turing's genius were his originality, his ability to control abstract thought by concrete illustration, and his preference for always working things out for himself. The freshness of his mind, his love of inquiry, and his relish for the comic, made him a lively and stimulating companion.

R. O. Gandy

Prof. C. R. S. Tenniswood

Charles Robert Sidney Tenniswood, professor of chemistry in Makerere College, University College of East Africa, died on May 22, following an accident in which his car skidded in the grounds of the College. At the time of his death, he was forty-seven and had been head of the Makerere Department of Chemistry for some nine years.

Charles Tenniswood graduated from King's (then Armstrong) College in the University of Durham with first-class honours in chemistry in 1927, being awarded the Freire-Morreco Medal and Prize for experimental work in the final year. The following year he was placed in the first division for the diploma in theory and practice of teaching before going on to three years of postgraduate research in organic chemistry under Prof. S. R. Clemo. His M.Sc. was awarded for a thesis entitled "Studies in the Synthesis of Bridged-Ring Compounds of the Quinuclidine Type", and he published papers on alkyl derivatives of ethyl malonate and ethyl cyanoacetate and on the lupin alkaloids.

Leaving the University of Durham in 1932, he was appointed head of the Chemistry Department of the Wandsworth Technical Institute, London, and then started a career of teaching which, except for the war years, was to last until his death. During 1941–44 he was seconded to the Ministry of Supply for work in the field of projectile development.

As a result of the De la Warr Commission in 1937, Makerere College, at Kampala in Uganda, had been planned for development to a university college serving all the territories of British East Africa; but the implementation of these proposals was delayed by the War. When Tenniswood arrived at the beginning of 1945, the level of teaching was of school standard and the teaching facilities consisted of one small and poorly equipped laboratory. At the time of his death nine years later, he had seen his first batch of degree students successful in their London B.Sc. Examination and had brought almost to completion the first of the new laboratories, which are giving East African undergraduates facilities in chemistry quite as good as they could enjoy in a British university. It was natural that senior members of the staff should have to bear a heavy burden of administration in the early days of a university. Tenniswood made invaluable contributions in this direction, with his great care for detail and unlimited energy. At the time of his death he was dean of the Faculty of Science and for several years had represented the Academic Board on the College Council. By his students he will probably be best remembered for the great enthusiasm that he brought to the teaching of chemistry, an enthusiasm which spared no pains to provide an interesting course and which infected his hearers with his own love of his subject. His many other duties had prevented him bringing to conclusion the researches that he started in East Africa. His earlier interest in plant alkaloids led him to investigate some of the many unknown active plant materials which have been used for years in native medicines.

Tenniswood's death is felt no less by his colleagues than by his students. His integrity and forthrightness were appreciated in personal dealings as well as in the many boards and committees on which he served, and he had a wide range of friends both in the College and in life outside. Growing colleges such as Makerere can ill afford to lose men of Tenniswood's loyalty and calibre, and his untimely death is keenly felt by all concerned.

Ralph F. Naylor

Dr. J. W. Fisher

Dr. J. W. Fisher, whose untimely death at the age of fifty-three was recently reported, was a member of the Royal Naval Scientific Service, having served with the Admiralty since 1939. He studied physics and mathematics in the University of London, where he obtained his Ph.D. in 1924. Having completed his postgraduate studies at Göttingen and Munich, he studied medicine and took his M.R.C.S. and L.R.C.P. and became house physician at Westminster Hospital. Before joining the Royal Naval Scientific Service he was engaged on research and exploration in Britain and in India on behalf of the Anglo-Iranian Oil Co.

While in the service of the Admiralty, Fisher's work was mainly directed to the solution of a number of highly intricate problems relating to the propagation, generation and reception of sounds in the sea. He brought to these problems a wide knowledge of basic physics and quite outstanding mathematical ability, coupled with the power of seeing the basic problem and to approximate—a gift which raises mathematics from a technique to a fine art. He held, with Stokes, that series solutions are devoid of elegance and showed great ingenuity in reducing his solutions to neat closed forms. The outstanding quality of his theoretical and experimental work was recognized when, in 1949, he was awarded special merit promotion to the rank of senior principal scientific officer by the Interdepartmental Scientific Panel.

Fisher had a gift for terse and pithy expression often combined with an amusing use of analogy based upon his medical experience. He had many interests apart from his scientific work, the most notable being an authoritative knowledge of antiques. He specialized in Chinese works of art—in particular, jade and carpets. With all this, he still found time to engage in farming on a small scale.

Men like Fisher are rare in any walk of life and his loss is much felt by his colleagues both in the Royal Naval Scientific Service and outside.

NEWS and VIEWS

Zoology at Bedford College: Prof. H. Munro Fox, F.R.S.

Prof. H. Munro Fox, who is just retiring from the professorship of zoology in the University of London at Bedford College, has occupied this chair since 1941; previously he had been Mason professor of zoology in the University of Birmingham from 1927 until 1941. After graduating in zoology from the University of Cambridge he joined the staff of the Imperial College of Science and Technology, London, in 1913, and after five years of war service returned there in 1919. Afterwards he was lecturer in biology at the School of Medicine, Cairo, during 1919–23. He then returned to Cambridge as a Fellow of his old college, Gonville and Caius, and also held the Balfour Studentship during 1924–27. During this period he organized and led a zoological expedition to the Suez Canal.

Prof. Fox's earlier investigations were in the field of marine biology and while in Cairo he studied the reproductive cycle of *Centrechinus setosus*, which, in the Red Sea, shows a well-marked lunar rhythm. The observations on this sea-urchin and other animals and plants showing supposed lunar periodicities were summarized in his book "Selene, or Sex and the Moon". His main interests, however, have been in the field of experimental zoology and for many years he has specialized in the study of animal pigments, more particularly the respiratory pigments of invertebrates. His researches and many publications in this field and also on respiratory movements in Polychaeta, Insecta and more recently *Daphnia*, either alone or in collaboration with his students, have opened up a very wide field of research. Prof. Fox has been the editor of *Biological Reviews* since 1926 and has taken a very active part in the promotion of international relationships among biologists. After the Second World War he visited various European universities on behalf of the Royal Society, and helped in the re-establishment of the International Union of Biological Sciences, and after being secretary of the Union for some years was president during 1950–53. He also served for five years on the Advisory Council of the Department for Scientific and Industrial Research. In 1953 he was appointed Fullerian professor of physiology in the Royal Institution.

Chemical Pathology at St. Mary's Hospital Medical School, London: Prof. A. Neuberger, F.R.S.

Dr. A. Neuberger, of the National Institute for Medical Research, has been appointed to a University chair of chemical pathology tenable at St. Mary's Hospital Medical School, London. Dr. Neuberger, who is forty-six years of age, holds the degree of M.D. (Würzburg) and Ph.D. (London). He held a Beit Memorial Fellowship during 1936–40 and carried out research work at University College Hospital Medical School, London, until 1939. He continued his researches in the Biochemistry Department of the University of Cambridge until 1942 and has since been a member of the scientific staff at the National Institute for Medical Research. In 1945 he was adviser to the Medical Directorate, G.H.Q., Delhi. He was awarded the Julius Mickle Fellowship of the University of London in 1946. He has been a member of the editorial board of the *Biochemical Journal* since 1947 and its chairman since 1952. Dr. Neuberger has worked on a wide range of topics in the chemistry and biochemistry of amino-acids and proteins. His earlier researches were concerned with the use of dissociation constants for structural diagnosis in the amino-acid and protein field; this method was later used by him in a study of the structure of penicillin. In the amino-acid field he has been concerned with stereochemistry, in particular that of hydroxyproline, and with metabolic and nutritional aspects. He is an expert on biochemical genetics and has a special interest in the metabolic abnormality known as alcaptonuria. Recently, he has become interested in the problem of porphyrin biogenesis and has made important contributions to our knowledge of congenital porphyria. He is also engaged in the study of the biosynthesis and metabolism of collagen.

Committee of Public Accounts: Research Expenditure

The Committee of Public Accounts for the session 1947–48 recommended that the expenditure on the Vote for the Department of Scientific and Industrial Research, among others, should be covered by statutory authority other than the annual Appropriation Act, and, in evidence before the Committee in the following session, the Treasury promised to take the first convenient opportunity to embody the functions of the Department of Scientific and Industrial Research in a statute. No such opportunity, in the Treasury view, has yet arisen; and the Committee, in its third report for the session 1953–54 (pp. 44. London: H.M.S.O., 1954. 1*s*. 6*d*. net), expresses the opinion that, in view of the years that have elapsed since the Committee of Public Accounts first recommended legislation, and the expansion of the Department's expenditure during that period, the necessary Bill should be prepared at once, ready for immediate introduction when any opportunity presents itself. In commenting on expenditure, estimated at £213,000, on the construction of a new fishery research vessel for the Torry Research Station of the Department, the Committee points out that five other departments or grant-aided bodies are engaged on fishery research and have provided themselves with a total of twelve research vessels for various purposes, but that it was not clear how the activities of these departments and bodies and the Department of Scientific and Industrial Research are co-ordinated. The Committee is not satisfied that there is no overlap of functions and recommends further inquiry by the Treasury. There is also a comment on the cost of construction of the Mechanical Engineering Research Station at East Kilbride, for which originally £1,000,000 was provided in the 1949–50 estimates, increased to £1·5 million, provisional in 1950–51 and 1951–52, reduced to £1,264,600 in 1952–53 and increased to £2 million in 1953–54, which has now been set as an upper limit. The Committee is satisfied that the Treasury exercised close control over the constituent parts of schemes of this kind, but, though critical of the way in which estimates and ideas developed as the work proceeded, the Treasury made no comment on what may well have been the more important factor in a time of rising costs—the effect of Government retrenchment and the consequent delay in executing the scheme.

University Grants

Without advancing any fresh reasons in its third report for the session 1953–54, the Committee of Public Accounts again presses for the inspection of

the books and accounts of the universities relating to expenditure of non-recurrent grants by the Comptroller and Auditor General. The Committee is unconvinced by the Treasury objections as detailed in the special report last February (see *Nature*, **173**, 383; 1954), although it welcomes the appointment of a special committee of four to examine the universities' methods of contracting and of recording and controlling expenditure. Nevertheless it recommends that the matter be considered afresh by the Committee for the next session, and meanwhile it also recommends that the Comptroller and Auditor General should in future have access to the papers and records of the University Grants Committee relating to non-recurrent grants and also those which contain requests from the universities for assistance and the record of the consideration of them by that Committee. This persistent attempt to subject to close control expenditure which has been deliberately made the responsibility of a non-government institution, for reasons which are generally understood and approved, is disturbing. The proposals endanger an administrative device primarily designed to preserve the ancient freedom of British universities. Admittedly, the device will only endure so long as its value is clearly understood and approved, in Parliament and outside; but could not the Parliamentary and Scientific Committee usefully look into the question why academic freedom is subjected to this sustained attack by a committee of members of Parliament appointed primarily to ensure that the Government is not wasting public money and, secondly, to ensure that public money is not wasted by independent bodies?

Earthquake near Orléansville, Algeria

In the early hours of September 9, an earthquake occurred with an epicentre near Orléansville in Algeria. Most of the buildings in the town were damaged and many of them collapsed entirely. The Hotel Baudouin and two other hotels, the subprefecture, a college, two blocks of nine-story workers' flats, the hospital and the railway station were destroyed immediately. The cathedral in the marketplace and the Church of Saint Reparatus dating back to the fourth century were badly damaged; and part of the jail collapsed, killing ten prisoners. Almost the only large building which escaped damage was the mosque. Nine out of every ten houses in the town were rendered uninhabitable. Telephone and telegraph communications were interrupted, gas mains were torn out, and roads and railways in the neighbourhood were rendered useless. The villages of Ponteba and Vauban were reported heavily damaged and other villages in the area were in ruins. Altogether devastation was caused over an area of some forty square miles from Ténès in the north, southwards, and from Miliana in the east, westwards. The 160-ft. wall of the Oued Fodda dam was cracked, but was quickly repaired, though a main irrigation duct was dislocated and this latter caused considerable flooding. The smaller Lamartine dam is reported to have collapsed, also causing flooding. The shock was felt in Algiers but caused no damage there. Altogether the damage is estimated at four million pounds. There were more than 1,250 killed and some 2,000 injured in the district. Orléansville was a town of about 22,000 inhabitants.

The shock was recorded at many observatories. At the Royal Observatory at Edinburgh, *eP* was registered at 01h. 09m. 15s. G.M.T. and *iS* at 01h. 12m. 52s. G.M.T. There appears to be a distinct possibility that the shock was double, and that an aftershock was recorded on the Edinburgh seismogram in the coda of the first shock. This would make the initial time of the main earthquake 01h. 04m. 49s. G.M.T. The depth of focus was normal and there were large surface waves. Algiers Observatory registered sixty-nine tremors in the twenty-four hours following the main shock, fifteen of them being strong. According to records collected by Prof. J. P. Rothé and Mme. A. Hée, of Strasbourg, earthquakes are by no means uncommon in Algeria. The line of orogenic activity stretches from Gibraltar, along the Rif in Morocco and the Little Atlas mountains in Algeria to Sicily and thence to the Apennines in Italy and to the Alps. The epicentres in Algeria lie on the principal anticlinal axes. Between the years 1790 and 1949, fifty-four earthquakes originated from a focus with epicentre some fifty kilometres to the east of Orléansville, and in the same period thirty-eight shocks occurred which had another epicentre some twenty-five kilometres north-north-west of Orléansville. The region most susceptible to earthquakes in Algeria appears to be that immediately to the south-south-west of Algiers.

Silver Jubilee of the Indian Ceramic Society

The Indian Ceramic Society was inaugurated in the Banaras Hindu University on April 15, 1928, by the late Mahamana Pandit Madan Mohan Malariya, founder of the University; the silver jubilee therefore fell last year but, for various reasons, could not be celebrated until February 1954. The celebrations included the delivery of a presidential address, the reading and discussion of papers on the ceramic raw materials of India, and the opening of the Society's new headquarters within the Glass and Ceramics Department of the University. Prof. W. E. S. Turner was the chief guest during these celebrations. In his presidential address, Dr. Atma Ram described the efforts that led to the foundation of the Society and its early struggle for recognition. While discussing future policy, Dr. Ram commented on the great progress made during the past thirty years in ceramic science and in mechanization within the industry; he thought it equally important that the general outlook on matters of organization, planning and personnel had also progressed. He emphasized the need for caution in adopting mass-production methods in a country such as India, where consumption of many of the articles that would be produced is at present low. The symposium on ceramic raw materials was organized jointly by the Society and the Central Glass and Ceramic Research Institute. Its objects were to make an appraisal of the domestic resources of the raw materials needed by the Indian ceramic industry and to examine methods for their preparation and purification.

Geophysical Conference in South Africa

A successful conference on geophysical subjects was held during July 19–22 at the University of the Witwatersrand, Johannesburg, under the auspices of the Bernard Price Institute of Geophysical Research. The field covered recent determinations of the ages of rocks and their geological implications (eight papers), geodesy (four papers), crystal structure of the earth, including seismological and gravity investigations (eleven papers), geomagnetism (four papers), the mechanical properties of rocks, including the phenomena of rock bursts (five papers), the earth's

heat and its origin (five papers), the interior of the earth (four papers) and geophysical prospecting (four papers). Nearly a hundred scientific workers and interested persons from South Africa attended the conference. A number of visitors were from neighbouring British Protectorates and the Belgian Congo, and from farther afield came Dr. Francis Birch (Harvard University), Dr. Robert Stoneley (University of Cambridge) and Dr. C. J. Jaeger (Australian National University, Canberra). In addition, papers were received from M. A. Tuve and H. E. Tatel (Department of Terrestrial Magnetism, Washington, D.C.), from Prof. L. Cahen (Musée Royal du Congo Belge, Tervuren) and from the National Meteorological Service of Portugal. The papers will be published by the authors independently in various scientific journals.

Antwerp 'Zoo' Bulletins

Before the Second World War the Société Royale de Zoologie d'Anvers published a bilingual, French and Flemish, review termed *Zoo*, which was well known to visitors to the Antwerp Zoological Gardens. For financial and other reasons, this has not been restarted since the War. To some extent, it is now replaced by "Bulletins", limited to four numbers in the year, of which the first three are to hand, consisting of 24, 48 and 54 pages, respectively. They are issued by the Society under the general direction of Mr. Walter Van den bergh and the editorship of M. M. Palmans. The first number, July 1953, treats of the infection of penguins with plasmodium by Dr. J. Rodhain; the second is a description of freshwater fishes from the Belgian Congo, by Dr. Max Poll, many of which are on view in the Antwerp gardens; and the third treats of various aspects of the acclimatization of the okapi and has contributions by Dr. L. M. G. Guerden and Dr. Vendermander (Ghent), Axel Reventlow (Copenhagen) and C. S. Webb (London). They are all well illustrated by half-tone reproductions of photographs. The treatment is not fully technical but at the same time not popular, and they contain much useful information derived from actual experience. The second bulletin, that on fishes, with illustrations of thirty-four different species living in the Antwerp aquarium, shows that, apart from the scientific interest of some of them, there are a number that make attractive additions to an aquarium.

The Museums Association

The annual report of the Museums Association published in the July issue of the *Museums Journal* is a reminder of the growing status of these institutions and their increased usefulness to the community. For the Association, 1953–54 has been a year of exceptional activity, the beginning of a number of new ventures and marked by the continued improvement in its finances. The Handbook Panel issued its first publication and the Directory Panel is now collating the results of an extensive questionnaire. A technical certificate is now available to indicate the professional qualifications of those museum workers whose activities are in that particular field, and consideration has been given to the extension of the diploma scheme to other parts of the Commonwealth. As in previous years, the museum movement in Britain records with gratitude its great debt to the Carnegie United Kingdom Trust for its whole-hearted and liberal support.

Museum of Applied Science of Victoria: Report for 1953

In the report of the Museum of Applied Science of Victoria for the year ended June 30, 1953, it is interesting to note that the Museum intends to carry out radiocarbon (carbon-14) determinations in the near future. The few existing centres in Australia doing this work are unable to cope with all the demands, and the provision of a laboratory for this modern technique will be invaluable to Australian research workers. The acquisition of an 8-in. equatorial telescope in 1945 has resulted in a well-established and popular service to the public. With the generous assistance of a panel of honorary demonstrators from the Astronomical Society of Victoria, members of the public are able to observe the night sky.

Queen Elizabeth Forest Park

A guide to the National Forest Park, comprising Ben Lomond, Loch Ard and the Trossachs, has been compiled by Prof. John Walton, of the University of Glasgow. In commemoration of the Coronation of Her Majesty, it is fitting that this beautiful park should be named the Queen Elizabeth Forest Park. Of all the national forest parks, this is likely to be visited by the greatest number of the public; unlike the others, it is situated within easy reach of the large populations of Edinburgh, Glasgow and the industrial districts of the central valley of Scotland. Moreover, it includes part of the Trossachs, which has for many years attracted visitors in large numbers from all parts of the world.

The Forestry Commission in 1928 acquired land in the neighbourhood of Loch Ard, and with later acquisitions has brought under national ownership no less than 41,454 acres extending from Loch Venachar and the headwaters of the Forth over the summit of Ben Lomond to the shores of Loch Lomond. The area marches with the main part of the beautiful Trossachs. Plantations covering an area of more than 13,000 acres have been established, while there are nearly 20,000 acres of lochs and mountains which are available for those who find joy and recreation in exploring the wild countryside. Besides sections dealing with the geology, botany, bird and mammal life of the area, the guide contains an account of the structure and freshwater biology of Loch Lomond, Gaelic place names and their derivations, as well as an account of the Trossachs in literature. The guide also contains a useful Ordnance Survey map of the area. Guides cost 3*s*. each and can be obtained from H.M. Stationery Office.

Sea-horses in a School Laboratory

Many people regard sea-horses (*Hippocampus* sp.) as fictitious or heraldic or have heard of them only from mythological references in ancient literature. Apart from the excellent exhibit at the London Zoo, under the care of Mr. H. Vinall, and in a few seaside aquaria such as that at Plymouth, these animals are seldom seen alive in Britain. There are many laboratory difficulties in trying to maintain a stock of sea-horses; they do not acclimatize easily, refuse to eat and eventually die of starvation. Clean seawater has constantly to be procured, continuously to be aerated and maintained at a temperature of 75° F. by means of thermostatic control. The Edinburgh and East of Scotland Aquarium Society very enterprisingly showed some fine specimens at its annual

exhibition in 1953 and these were later transferred to the biological department of Loretto School. Although they were never given any formal lessons on the subject, a group of fifty schoolboys were given a surprise question in an examination paper on the habits of sea-horses. Their observations have been put together in a most stimulating article by A. S. Gillespie (*School Nat. Study J.*, **49**, 196; July 1954).

Protection of Plants

The thirty-fourth report of the Quebec Society for the Protection of Plants (Pub. Dept. Agriculture, Province of Quebec, May 1954; n.p.) includes, among other general matters, a number of papers presented at the annual meeting and also the papers contributed to a symposium on "Viruses and the Protection of the Plant Kingdom". These last range widely, and include studies of infection, identification, relationships of strains, the induction of mutants, host reaction, mutual adaptation in viruses and their hosts, resistance, immunization, agents of dissemination, and other topics.

Chemical and Plastic Materials Exhibition in Paris

The third Salon de la Chimie et des Matières Plastiques will be held at the Parc des Expositions, Porte de Versailles, Paris, during December 3–12. On each of the eight weekdays during this period a technical meeting will be held to discuss the following subjects: new vacuum techniques; perfumery and cosmetics; chromatography and ion exchange; applications of microscopy in chemistry; anti-fouling paints; electronic techniques in the service of chemistry; control and regulation systems in sugar refineries, and corrosion; and recent developments in plastics, and corrosion. Last year the Salon included 650 exhibitors from thirteen countries, and two hundred thousand visitors attended; this year the Salon will be even larger, and an area of just over six acres has been reserved. In all, there will be four separate but complementary exhibitions as follows: laboratory equipment (instrumentation, optical, testing, measuring, control and regulating equipment); chemical products (pure, industrial and finished products); chemical engineering (general and special plant); and plastics industry (raw materials, materials for processing, and manufactured articles). Concurrently the third session of the Chemical Engineering Conference will be held, when many of the problems encountered in the operation of modern factories will be reviewed. Further information on all these events can be obtained from the Commissariat Général, 28 rue Saint-Dominique, Paris 7e.

National Research Council of Canada: Post-doctorate Fellowships for 1954–55

The National Research Council of Canada has awarded sixty-eight postdoctorate fellowships for the year 1954–55 for research in the Council's laboratories. The fellowships, which are worth 3,000 dollars tax-free (3,500 dollars for married men), are awarded without regard to nationality to persons less than thirty-five years of age with a Ph.D. degree of a recognized university. The distribution of the awards between the various Divisions of the National Research Council is as follows: applied biology, 10; applied chemistry, 9; pure chemistry, 25; physics, 17; and radio and electrical engineering, 1. In addition, five fellowships will be held at the Prairie Regional Laboratory, Saskatoon, and one at Science Service of the Department of Agriculture.

Pesticides Group of the Society of Chemical Industry

The Society of Chemical Industry is forming a new Group—the Pesticides Group—based on the former Crop Protection Panel of the Society's Agriculture Group. The present membership of the new Group is about two hundred and forty, mainly derived from the former Panel, but with the now extended terms of reference it is hoped that the Group will be widely supported by individuals and firms with an interest in pesticides, but not necessarily in the field of agriculture. The inaugural meeting and dinner of the Group will be held on October 18. Further information can be obtained from the General Secretary, Society of Chemical Industry, 56 Victoria Street, London, S.W.1.

Advisory Council for Scientific and Industrial Research: New Members

The Lord President of the Council has appointed Dr. E. Ashby, president and vice-chancellor of The Queen's University, Belfast, Mr. S. Barratt, finance director of Messrs. Albright and Wilson, Ltd., Oldbury, Birmingham, Prof. E. A. G. Robinson, professor of economics, University of Cambridge, and Dr. C. Sykes, managing director of Messrs. Thomas Firth and John Brown, Ltd., Sheffield, to be members of the Advisory Council for Scientific and Industrial Research in succession to Prof. R. S. Edwards, Lord Halsbury, Sir Henry Hinchliffe and Mr. A. H. Wilson, who retire from the Council on September 30. Sir Hugh Beaver is to succeed Sir Ian Heilbron as chairman of the Advisory Council on October 1. The other present members of the Council who continue to serve after September 30 are: Sir Wallace Akers, J. Crawford, Prof. T. R. C. Fox, W. L. Heywood, Sir Philip Johnson, Sir Eric Rideal, Sir George Thomson and Sir Ben Lockspeiser (secretary).

Announcements

A course of twelve lectures and demonstrations on the theory of photoelasticity and the practical application of photoelastic methods to the investigation of two-dimensional stress distributions will be given in the Faculty of Engineering, University College, London, on successive Mondays (2–3 p.m.), commencing on October 11. A course of twelve lectures and demonstrations on recent developments in the photoelastic investigation of three-dimensional stress problems will similarly be given on Mondays, commencing January 31, 1955. The fee for each course is 7½ guineas, or 14 guineas for both (free to students of University College). Further information can be obtained from the Secretary of the College, Gower Street, London, W.C.1.

The Bone and Tooth Society will hold a symposium on "Vitamin D and Bone" on September 30 at the Institute of Orthopædics, 234 Great Portland Street, London, W.1, at 5 p.m. Sir Edward Mellanby will speak on "Vitamin D and Nutrition" and Dr. E. Kodicek on "Balance Studies of Vitamin D in the Rat". There will also be a joint contribution from Dr. J. Anderson, Dr. C. E. Dent and Dr. B. Senior on "Vitamin D and Phosphate Excretion". Further information can be obtained from the Secretary, Bone and Tooth Society, Biochemistry Department, Institute of Orthopædics, Royal National Orthopædic Hospital, Brockley Hill, Stanmore, Middlesex.

SIXTH COMMONWEALTH ENTOMOLOGICAL CONFERENCE

At the Sixth Commonwealth Entomological Conference, held in London during July 7–16, there were fifty-five delegates, a greater number than ever before, and these included representatives from nearly all the countries of the British Commonwealth. The open meetings attracted a large attendance of entomologists from Britain and overseas, and a wide field of subjects was discussed.

The principal advances in economic entomology continue to be in the development and application of synthetic insecticides and in the study of problems arising from their use. Dr. H. G. H. Kearns (University of Bristol Fruit Research Station) reviewed the synthetic insecticides used on field crops and the methods of applying them. It is more difficult to treat field crops than plantation or orchard crops, and the margin of profit limits what can be done. These considerations apply particularly to peasant-grown crops, for which dusting, though an inefficient way of using toxic materials, has the advantage of requiring no water and of permitting the use of simple equipment.

The application of insecticides from aircraft was dealt with first by Mr. D. Yeo (Colonial Insecticides Research Unit, Tanganyika), with particular reference to tsetse fly. Methods using residual deposits are not economic against species spread through savannah woodland; but in large-scale experiments using 'space sprays' that deposit toxic droplets directly on the fly kills approaching 100 per cent have been reached. The behaviour of droplets of such a size (about 50 μ) that they neither impact on the canopy nor fail to settle is greatly affected by atmospheric turbulence: application is thus restricted to brief periods around dawn and dusk, when conditions are still, and this renders the use of aircraft uneconomic. Dr. R. C. Rainey (Desert Locust Survey) discussed developments in spraying flying locust swarms from aircraft. Methods of graphical analysis of the factors involved, together with laboratory indications that locusts are far more susceptible to insecticide when flying than when resting, have provided the background to aerial attacks on swarms recently invading East Africa. By bringing together data from many sources, estimates of efficiencies and costs have been obtained which suggest that the method is not seriously more expensive than hopper-baiting, to which it is complementary, making it possible to attack locusts throughout their life-cycle.

Dr. A. M. Massee (East Malling Research Station) illustrated the effect of insecticides on the balance of animal populations by the history of certain orchard pests. The mite *Metatetranychus ulmi* became a serious pest after the adoption of tar–oil washes, which are non-toxic to its winter eggs but killed many of its predators that hibernate on the tree, and the use of DDT and organo-phosphorus compounds made matters worse. DDT also favours woolly aphis, *Eriosoma lanigerum*, by destroying its parasite, *Aphelinus mali*; on the other hand, it has virtually eliminated the apple capsid, *Plesiocorus rugicollis*, which had become an important pest under the previous spray programme. Spider mites can now be controlled by summer ovicides that are relatively harmless to beneficial insects and mites; this advance underlines the need for more selective rather than more toxic insecticides.

In opening the discussion on the development of resistance to insecticides, Dr. J. R. Busvine (London School of Hygiene and Tropical Medicine) said that authentic cases, among which pests of medical importance preponderate, are mostly of recent occurrence, and it is not clear whether this results from a more widespread use of insecticides or from the way the modern ones act. The possibility and speed of development of resistance depend on the frequency of occurrence and effectiveness of resistant genes in the original population, the intensity of selection and the rate of reproduction. Little is known of the mode of action of resistance: one mechanism appears to be the conversion of toxic to innocuous compounds; but another one, differently inherited, is required to explain resistance to 'knock down'.

Dr. I. Thomas (Plant Pathology Laboratory, Harpenden) opened the discussion on the estimation of losses from pests by referring to early work based on mechanical simulation of damage, and then outlined the methods used in Britain by the National Agricultural Advisory Service, under the guidance of the Pest Assessment Committee. He emphasized that pest damage is only one of several factors affecting crop yields and that, especially in under-developed countries, it may not be the limiting one. His colleague, Mr. A. H. Strickland, described in more detail the use of insecticides to obtain differences in pest density on experimental plots. Regressions of yield on infestation thus obtained for each district can be integrated with rapid district-wide assessments of infestation to provide valid estimates or even forecasts of yield losses. A subsidiary development is the collation of pest densities with ecological features, thus enabling situations associated with high infestations to be defined and avoided. Mr. Q. A. Geering (Cotton Research Station, Uganda) described a method used in Uganda for studying losses caused by cotton mirids. This utilizes single-row plots from which the pest is repelled by an insecticide, and is valuable in the case of mobile insects, for which ordinary plot methods break down. The results show how a plant which flowers over a considerable period can ultimately compensate for severe early damage, the real loss being in time rather than in yield.

Dr. W. R. Thompson (director of the Commonwealth Institute of Biological Control) outlined recent attempts to control two scale insects accidentally imported into Bermuda that have attacked the dominant shade tree there, a species of cedar that is unique to the island and, perhaps for that reason, highly susceptible to scale attack. Although some one and a half million individuals of forty species predatory or parasitic on scales were introduced, only two species, both Coccinellids, have become established. It appears that predators, as well as parasites, may have highly specific host-relationships. The Coccinellids now show signs of holding scale infestations below a level lethal to the surviving trees; but the lack of more striking success in a biological control operation on an island is surprising and emphasizes the need for further research if the results of such experiments are to be understood.

The principles underlying the biological control of weeds were discussed by Mr. J. R. Williams in a

paper read by Dr. R. Mamet, both of the Department of Agriculture, Mauritius, where spectacular control of the introduced weed *Cordia macrostachya* has been effected by the leaf beetle, *Schematiza cordiae*. Essentially they involve exhaustive tests to show that the insect introduced is restricted to the weed to be controlled; the danger of the evolution of strains adapted to other, desirable plants after the elimination of the undesirable one seems slight, because the period during which intense selection of such strains would operate, following the rapid collapse of the weed population, would perforce be short.

In the discussion on pests of tropical cereal crops, both the opening speakers stressed the need for special research, and the Conference endorsed this view. Dr. H. F. Barnes (Rothamsted Experimental Station) reviewed recently acquired records of the occurrence of certain important grain midges, and pointed out that the existence of biological races necessitates experimentation to show whether sorghum midge, which is a particularly serious pest, is a single species being spread with seed or a complex of species that have arisen independently by convergent evolution. Mr. J. Bowden (Department of Agriculture, Gold Coast) said that damage by stemborers had been insufficiently appreciated and investigated because of the preoccupation of entomologists with cash crops. The two needs are critical taxonomic and biological studies of the groups concerned, and standardized ways of assessing infestation and damage; the methods developed in the Gold Coast, though simple, seem adequate.

Mr. G. V. B. Herford (director of the Pest Infestation Laboratory) spoke of the increasing realization of the magnitude of problems of stored-product pests, particularly those of the Colonial territories, where a number of research and advisory units, with which close liaison is being maintained, are now engaged. Notable technical developments include the extended use of the fumigation of bagged produce under gas-proof sheets, and greater provision for bulk storage of grain, either in silos utilizing circulatory fumigation or in sealed underground pits.

Dr. R. C. Fisher (Forest Products Research Laboratory, Princes Risborough) began the discussion on problems of forest entomology, and referred to another example of the establishment in a tropical region of a unit linked with a research institute in Britain, namely, the team studying bark beetles in West Africa. In this investigation and in those carried out at the Forest Products Research Laboratory, the emphasis is on the study of the biology of the insect and the relation of its attack to the history and condition of its host timber. Dr. F. T. Bird (Division of Forest Biology, Canada) gave an account of the use of virus diseases of European origin against two introduced sawflies. The virus, which has maintained an extreme virulence, has been artificially disseminated and gives rise to epizootics in succeeding years, being transmitted from year to year via the egg. The mortality is dependent on the population density and habits of the sawflies, and at low densities is greater in the spruce sawfly, the eggs of which are laid singly and whose larvæ feed singly.

Mr. W. V. Harris, who opened the discussion on termites, outlined the programme and progress of the Colonial Office Termite Research Unit, of which he is in charge. He mentioned some interesting points that have already emerged from the rapidly accumulating data on termite distribution and ecology in East Africa, and directed attention to the dispersal of injurious dry-wood species that is taking place around the tropics.

Mr. L. G. Putnam (Division of Entomology, Canada), in a paper read by Mr. A. B. Baird, discussed developments in grasshopper research and control in Canada. Grasshoppers, unlike locusts, are not strictly gregarious, and do not normally undertake long flights. Outbreak centres thus do not exist: overall abundance appears to depend on weather factors, now being analysed, and as the insects are univoltine and lay their eggs, which overwinter, in or adjacent to stubble, the intensity of damage is determined by the degree of juxtaposition of successive crops. Dr. B. P. Uvarov (director of the Anti-Locust Research Centre) dealt with the more complex dynamics of locust plagues, involving not only fluctuations in numbers but also changes in the extent of the populated area and qualitative differences between solitary and swarming populations. Quantitative studies of numerical fluctuations and of their causes, especially biological ones, are now being pressed forward. A connexion has been demonstrated between large-scale swarm-displacements and movements of air masses, and the more mysterious movements that solitary adults are known to make are being studied. Recent work suggests that gregarious behaviour arises from conditioning, and persists even though the conditioning factors no longer operate.

Dr. C. H. N. Jackson (Tsetse Research Laboratory, Tanganyika) discussed the principal methods that have been used for controlling tsetse. These mostly depend on the selective destruction of some essential feature of the fly's environment, such as the vegetation characterizing the favoured breeding site or affording protection against desiccation, or the animals that constitute the food supply or a principal element in it. Insecticides are effective, though rather expensive; their use leaves the environment unaltered and discloses the interesting likelihood that fly populations are unable to recover after reduction below a certain level. Some results of the empirical control methods have been explained by research on tsetse physiology and behaviour, but much more of such work is needed.

Dr. W. J. Hall (director of the Commonwealth Institute of Entomology), in opening a discussion on the supply and training of taxonomists, said that the existing provisions for taxonomic research and for the identification of insects and mites of economic importance are inadequate. Substantial increases in staff are needed in organizations connected with these activities, which are interdependent. A number of other suggestions for improving the situation were discussed, and a committee was set up to make recommendations.

A full report of the proceedings, including the resolutions adopted by the Conference, will be published later in the year by the Commonwealth Institute of Entomology, together with reviews of the progress of economic entomology in the Commonwealth countries since 1948.

During the Conference, delegates visited Rothamsted Experimental Station, the Silwood Park Field Station of the Imperial College of Science and Technology, London, and the Pest Infestation Laboratory of the Department of Scientific and Industrial Research. These visits, together with certain social occasions, provided the opportunity for informal discussion between entomologists from many widely separated countries that is so valuable a feature of these Conferences.

COMPARATIVE ENDOCRINOLOGY OF VERTEBRATES

AN international symposium on the comparative endocrinology of vertebrates was held in the Zoology Department, University of Liverpool, during July 12–16. It was made possible by the generous financial support of the Rockefeller Foundation and the United States National Science Foundation. The Derby professor of zoology, Prof. R. J. Pumphrey, on behalf of the University, officially welcomed the participants, who numbered about seventy-five. The symposium was divided into two parts, the first entitled "The Comparative Physiology of Reproduction" being under the chairmanship of Prof. S. Zuckerman; for the second part, on "The Hormonal Control of Water and Salt-electrolyte Metabolism in Vertebrates", Dr. S. J. Folley took the chair.

The first two days were devoted to a comparative survey of reproduction, starting with a paper on fish by Prof. W. S. Hoar (Vancouver), who, even though confining his survey to the teleosts, surprised many of his audience with the wide variety of reproductive patterns ranging from oviparity to viviparity met with in the bony fish. In discussion of this paper, Dr. A. S. Parkes raised the interesting question of how the sperm penetrates into the ovarian follicles in those forms in which intrafollicular fertilization occurs. This question could not be answered.

Prof. G. J. van Oordt (Utrecht) dealt with the male amphibian, his paper describing an experimental analysis of seasonal fluctuations in spermatogenesis in frogs which emphasized the part played by variations in sensitivity of the seminiferous tubules to pituitary gonadotrophins. In the discussion, Dr. H. Tuchman-Duplessis referred to experiments on the newt which suggested that cyclic variations in pituitary gonadotrophic activity may be another factor involved in seasonal changes in spermatogenesis in amphibia. Dr. C. L. Smith (Liverpool) in surveying reproduction in female amphibia discussed the role of exteroceptive factors such as rainfall and temperature in controlling pituitary activity via the hypothalamus. He described experiments on the relation between thyroid activity and the sympathetic system which might bear upon the possible participation of an adrenergic component in the functional pathway between the hypothalamus and the hypophysis.

Reptiles, which have been comparatively little studied by endocrinologists, were surveyed under four heads, Sauria, Ophidia, Crocodilia and Chelonia, by Dr. R. Kehl (Algiers) in a joint paper with C. Combescot. Much of the paper was taken up with a description of Dr. Kehl's own work on the Algerian saurians, *Uromastix* and *Acanthodactylus*, which is providing much needed additional information about this class. Dr. M. R. Miller (California), in the discussion, described Californian reptiles in which the male interstitial cells show no evidence of endocrine activity. The meeting entered upon less exotic ground with a stimulating survey by Dr. A. J. Marshall (London) of reproduction in male birds, which included some slides illustrating his own observations on the periodic appearance of cholesterol-positive lipids in the testes. His references to the work of K. G. Wingstrand and particularly that of J. Benoit and I. Assenmacher, which suggests that the gonadotrophic function of the pituitary in birds is stimulated by a chemotransmitter of neurosecretory origin passing down the pituitary portal vessels, followed by an all-too-brief exposition by Prof. Benoit himself of his elegant experiments, aroused much interest. This prompted Prof. Zuckerman, who earlier as chairman had eschewed controversy by virtue of his office, to express scepticism as to the completeness of the experimental evidence for the involvement of the pituitary portal vessels in the hypothalamic control of pituitary function as postulated by Benoit for birds and by G. W. Harris for mammals. Reproduction in female birds was surveyed by Dr. W. R. Breneman (Indiana), who, in the course of his exposition, described cytological work carried out by his colleague, F. Payne, on the avian pituitary in various reproductive phases. Evidence that the avian ovary produces progesterone and androgen as well as œstrogen was presented. This paper gave rise to discussion on, among other topics, the mechanism which determines the number of eggs in a clutch. This is probably neurogenic, and it seems possible that it may be more or less analogous to the suckling stimulus in mammals which, if intense enough, can stop the ovarian cycles. This theory involves the idea that the brood spots of birds are homologous with the mammæ of mammals and so may be sensitive to prolactin, as may be the ventral glands in the Chinese swifts said to secrete the edible birds' nest cement, prized by gourmets as an ingredient of soup.

Prof. Zuckerman at this point exchanged the role of chairman for that of lecturer and, with characteristic scholarship, surveyed the mammals in a joint paper with P. Eckstein. His main thesis in reviewing the manifold reproductive patterns found in this class was that many of these variations may not be differences in kind so much as components of a continuous spectrum. In discussing this paper, Dr. S. J. Folley cited the domestic cow as a probable example of a form from which a primitive breeding season has been eliminated by selective breeding. This was followed by diverting exchanges between Prof. Zuckerman and Dr. Parkes, who pleaded for the simple view of natural phenomena. Dr. L. Harrison Matthews (London) then undertook a wide survey of reproductive processes in vertebrates in a paper the topic of which was the evolution of viviparity. The discussion on this paper was notable for an impressive and scholarly contribution by Prof. E. C. Amoroso in which, after considering the adaptations which viviparity has necessitated, he drew a penetrating parallel between the increasing complexity of the endocrine function of the placenta and the lengthening of pregnancy. The comparative survey was concluded by a paper by Dr. E. Witschi (Iowa) on vertebrate gonadotrophins which was mainly occupied by a consideration of results obtained with an assay technique based on plumage changes in the weaver finch. He concluded from his results that the luteinizing and interstitial-cell-stimulating hormones are separate and distinct pituitary hormones, a conclusion which, however, did not command the support of two of his compatriots, Drs. R. O. Greep and J. H. Leathem.

The third day of the symposium was occupied by papers on the effects of sex hormones in vertebrates. Dr. J. M. Dodd (St. Andrews) began with a survey of the position in fish and lower chordates, in the course of which it became evident that his results lead him to differ somewhat from the views of D. B. Carlisle on the endocrine function of the sub-neural gland in ascidians which some regard as a primitive

pituitary. Dr. Carlisle intervened in the discussion to clarify his position. Dr. L. Gallien (Paris) described experiments on the effects of sex hormones on sexual differentiation of the larvæ of amphibia. It is possible to achieve total sex inversion in amphibians by administration of the appropriate (mammalian) sex hormone at an early enough stage, showing that the development of the gonocytes is controlled not by genes but by endocrine factors arising out of the competing influences of the gonadal cortex and medulla. Dr. R. M. Fraps (Beltsville), in dealing with birds, described interesting experiments on the mechanism of ovulation in the domestic hen which indicate that the secretion of ovulating gonadotrophin (LH) by the pituitary is called forth by a progestogen (progesterone itself?) secreted by the follicle next due to ovulate. The secretion of the progestational hormone is probably evoked by pituitary luteotrophin (prolactin). In the discussion on this paper Prof. Benoit described among other things the masculinizing effect of cortisone on ducks.

Dr. J. H. Leathem (Rutgers), to whom the paper on mammals was entrusted, discussed important species differences in the effects of steroids on the reproductive system of both male and female. Dr. T. Mann, commenting on this paper, illustrated this point by references to the marked differences between various species of mammal as regards the respective sites of origin of the fructose and citric acid found in the seminal plasma. Dr. A. Jost (Paris) concluded this part of the symposium with a paper describing his investigations on the effects of sex hormones on sexual differentiation in the fœtus, which show that this is not a continuous process; rather, there occurs a critical period of testicular activity during which the character of the sexual structures is determined for life. Experiments involving hypophysectomy by the rather drastic procedure of decapitation (which, incidentally, is not fatal to the fœtus) indicate a gonadotrophic function for the fœtal pituitary. His admiration for the elegance of Dr. Jost's experiments tempted the chairman into a gentle tilt against the chemists, who, however, found a champion in Dr. Folley. In a masterly summing-up of this part of the proceedings, Prof. Zuckerman referred to the unique character of the meeting thus far, so broad and all-embracing had been the field covered. He reminded his audience that despite the astonishing variety of the reproductive patterns encountered even within one class, the underlying mechanisms seem nevertheless basically the same all through. It was good to hear Prof. Zuckerman predict that endocrinology will soon emerge from the "ACTH–cortisone era".

In opening the second part of the symposium, the chairman, Dr. Folley, referred to the evolution of devices for conserving water so as to preserve the aquatic environment necessary for the aqueous cell chemistry which is the basis of life. In considering the role of the endocrine system he mentioned recent achievements such as the discovery of aldosterone and the synthesis of the oxytocic polypeptide which can only serve to encourage further efforts in this field. The first paper, given by Prof. E. J. Conway (Dublin), began with a fundamental treatment of ionic equilibria in isolated muscle tissue before proceeding to consider the application of these principles in studies involving the adrenal cortex. It was interesting to learn that adrenal corticoids can influence ionic transport through the cell membrane of the yeast cell. Prof. H. Heller (Bristol) in a paper on mammals described the various physiological stimuli (dehydration, stimulation of vagal afferents, suckling, etc.) which cause secretion of the pressor-antidiuretic hormone. An old adage of the Hogben school, to the effect that when one measures hormone excretion in the urine one may be merely studying kidney physiology, came to mind in connexion with the mention of findings which suggest that the kidney may convert pressor-antidiuretic hormone into a less biologically active form prior to excretion. In comment upon a point raised by Prof. Heller's paper, Dr. Folley referred to the careful experiments of Mrs. M. H. I. Dodd at Shinfield which indicate that neither the lactating state itself nor the application of the milking stimulus has any detectable effect on the amounts of pressor-antidiuretic hormone and oxytocin in the posterior lobe of the goat. He also pointed out that evidence of differential secretion of the two posterior lobe principles has been provided by the work of G. Peeters, of Ghent, who showed that suckling antidiuresis in water-loaded cows could be inhibited by mild fright, while the milk-ejection reflex (believed to involve oxytocin secretion) was not affected. An interesting contribution to the discussion came from Dr. F. G. Hofmann, who described a creature of the American desert, the kangaroo rat, which is geared to maximum water conservation and shows a great impediment to water excretion, yet its response to pressor-antidiuretic hormone is equal to that of the ordinary rat.

A paper on amphibia was read by Dr. W. H. Sawyer (New York). He emphasized the key position of this class which, situated as it is between water and dry land, may provide the best experimental medium for elucidating the basic principles of salt and water balance. Dr. Sawyer visualized the neurohypophysis as playing the primary part in regulating water balance and the adrenals as having precedence in regulating salt metabolism. He felt that, for amphibia as for mammals, the respective roles of the two glands are complementary rather than antagonistic as so often regarded. In the ensuing discussion, Dr. C. Barker Jørgensen described experiments, partly with K. G. Wingstrand, on section of the supraopticohypophysial tract in *Rana temporaria* which resulted in a decrease of neurosecretory material but did not affect the rate of water uptake. Then Dr. V. Capraro (Milan) read a joint paper with M. L. Garampi describing experiments on effects of posterior-pituitary extracts on the rate of water flow through the isolated frog skin which indicate that mechanisms more complicated than simple changes in pore size are involved. As pointed out by Prof. Pumphrey, such results are likely to depend to an important degree on the season in which the frogs are taken, since the winter frog is physiologically a very different creature from the summer frog.

In the final session the first paper was by Prof. M. Fontaine (Paris), who gave an excellent general survey of the endocrine control of water and salt metabolism in fish. He was followed by Dr. D. C. W. Smith (St. Andrews) with an admirable account of some of the interesting work in progress at the Gatty Marine Laboratory on the relation between the endocrines and salinity tolerance in Salmonidae. The thyroid hormone and pituitary somatotrophin seem to be of importance here. The last paper was given by Dr. I. Chester Jones (Liverpool), who in refreshing style surveyed the role of the adrenal cortex in salt and water metabolism in vertebrates. In the dis-

cussion, observations on water diuresis in patients with adrenal insufficiency were described by Dr. A. Slessor, while Dr. M. Ginsburg described experiments on the relation between the adrenals and the rate of disappearance of injected pressor-antidiuretic hormone from the blood in rats.

In the course of both parts of the symposium there were references from time to time to a dictum attributed to a distinguished zoologist not present at the meeting, to the effect that it is not the hormones themselves which evolve but rather the uses to which they are put. The chairman briefly returned to this concept in his final summing-up. He regarded it as inherently improbable and cited a number of facts which suggest that hormones are suitable material upon which the evolutionary process can work. This prompts the thought that if a sequel to this symposium is organized in a few years time—and in view of the evident success of the present one it is to be hoped that this will be the case—then perhaps a suitable theme will be "The Evolution of the Endocrine System".

If the above suggestion is acted upon, it would please many if the sequel were held under the same auspices, for the atmosphere of this symposium was extraordinarily pleasant and all the arrangements reflected great credit upon the originator and organizer, Dr. I. Chester Jones. This was acknowledged in a graceful speech at the end by Prof. Benoit, as was the pleasant hospitality accorded to the participants in functions arranged by the Merseyside Civic Society, the University of Liverpool and Prof. Pumphrey.

By arrangement with the Society for Endocrinology, the proceedings will be published as soon as possible in two volumes (Nos. 4 and 5) of the recently established series of *Memoirs* of that Society, the Royal Society having made a generous grant towards the expenses of publication.

S. J. Folley

PHYSIOLOGY IN HUNGARY

THE twentieth (anniversary) annual conference of the Hungarian Physiological Society was held during July 8–10 in Budapest, under the presidency of Prof. Brunó Straub, and to mark the occasion the Hungarian National Academy of Sciences invited a number of guests from other countries to attend the meetings and to participate in the discussions. The programme, which contained 128 communications, demonstrated both the high quality of work in progress in the fields of physiology, biochemistry and pharmacology, and also the remarkable number and keenness of the younger generation of Hungarian scientific workers. Besides these papers, which were divided into three concurrent sections, there were plenary sessions, the first being devoted to a general report by Prof. G. Romhányi (University of Pécs) on the most recent discoveries relating to biological structure and function, and the others to lectures and communications by the foreign visitors.

From neighbouring countries came, among others, the Polish biochemists and physiologists, W. Niemerko (now director of the Nencki Institute, soon to return from Lódz to new quarters in Warsaw) and W. Missiuro; several Czechoslovak guests, including Dr. E. Gutmann (who at one time worked in Oxford); the Rumanian medical physiologists, Danielopulo and Julius Nitzulescu; and Prof. Gotséeff, of Bulgaria (one of the pupils of the late Sir Joseph Barcroft). The U.S.S.R. sent Prof. P. S. Kupalov (a former colleague in years gone by of Prof. A. V. Hill), Prof. S. C. Koschtojanz, the comparative physiologist, with the neurologists R. Kavetsky and A. Vorobyov. From the United Kingdom came the present writers, and from Germany the biophysicist Prof. Havermann (Berlin).

For more than twenty-five years, especially since the fundamental work of Szent-Györgyi and Straub in 1941 on the relations of actin and myosin, Hungarian physiology and biochemistry have been renowned for interest in the mechanism of muscular contraction. This was particularly in evidence at the present meetings, and for reasons of personal interest we shall report upon it a little more fully. Subjects which came under lively discussion included the effects of various extractants upon the appearance of muscle fibrils under the polarizing and electron microscopes; the early rapid phase of volume diminution accompanying the action current; the binding of metallic ions (especially Ca^{++} and Mg^{++}) by actin and myosin; and comparison of these proteins with others in this respect. The binding of Ca^{++} by muscle mitochondria was also reported upon. Interesting discussions were evoked by new investigations of the bound nucleotides in muscle and other cells, not only by Hungarian workers but also by Niemerko from Poland. A further topic was the cholinesterase activity of the mero-myosins prepared by tryptic hydrolysis; all of it was found to be in the L-mero-myosin just as all the adenosine triphosphatase actuity is in the H-mero-myosin. Among the workers presenting these papers were, with their many collaborators, E. Ernst, F. Guba, T. Erdös, G. Feuer, E. Biró, M. Bárányi and E. Varga.

Dr. I. Banga described some recent developments of her work on elastin, particularly in relation to the dependence of its elasticity on provision of water. Since elastin itself cannot bind water, the presence in the neighbourhood of water-binding collagen is essential. Dr. Banga and her husband, Prof. Joseph Baló, who directs one of the institutes of pathology in the University of Budapest, are much concerned with problems such as those of arterio-sclerosis.

Prof. Straub, while maintaining his interest in actin, has turned his attention also to protein synthesis. Papers from his laboratory included those on penicillinase synthesis in *B. cereus*, and on amylase synthesis in pancreas homogenates, in the presence of adenosine triphosphate. Interesting effects of ions on glutamine synthesis were also reported.

At the conclusion of the conference, the foreign visitors, together with some of their Magyar hosts, made excursions to the provinces to see the Freshwater Biological Institute on the shores of Lake Balaton, and the Universities of Pécs and Debrecen. The Biological Station at Tihány, where in the past several British investigators have worked, is in good condition, and in many ways well equipped, especially with a fine library. Under the direction of Dr. Bela Entz and Mr. I. Konok, work is proceeding on the hydrobiology of the lake with reference to the fisheries, and on the comparative physiology of invertebrates, including insect hormones. There is space for about twenty workers, and the collecting facilities include a good motor-cruiser.

The University of Pécs was first founded in A.D. 1367; but ceased to exist when the great majority of its students were killed in resisting the

advance of the Turks—it was not re-founded until the present century. The town lies all on the slopes of a pleasant range of hills, and still has two mosques and a minaret among its architectural remains. The University consists primarily of the Faculties of Medicine and Law. Scientifically, it occupies a special position, as nearly all its professors are Academicians, and the National Academy of Sciences takes a particular interest in its progress. In the Department of Physiology, headed by Prof. E. Ernst, visitors were able to see ingenious apparatus for measurement of rapid volume changes using a piezo-electric quartz membrane, and micro-calorimeters for recording heat-production of muscles without contact between the tissue and the thermo-couples. One of the chairs of pathology is held by Prof. C. Donhoffer (a pupil of the late J. J. R. McLeod at Aberdeen); under his leadership interesting work in nutritional science is proceeding, especially on the effects of many different factors on the selection and intake of food by the rat. In the Department of Neuro-physiology (Prof. K. Lissák) much work on conditioned reflexes is under way; this was naturally of great interest to the Russian and Polish specialists. The Institute of Anatomy and Embryology, under Prof. J. Szent-Agothay, was also full of activity, mainly on three lines: neuro-hormonal correlations studied by lesions of the central nervous system; a new approach to 'neuro-taxis' in the study of the means whereby outgrowing axons find their way to their presumptive connexions in ganglia or central nervous system; and developmental neuro-anatomy. Here Dr. G. Székely has obtained results of much interest by homoplastic heterotopic eye transplantations in the newt, giving reversed reflex reactions to prey after innervation. Learning to overcome this is possible with half an eye but never with a whole one. Lastly, in the Department of Histopathology (Prof. G. Romhányi) work is well advanced on the study of artificial birefringent fibrils of polymerized deoxyribonucleic acid.

Throughout the conference, Magyar hospitality was at its most charming, and the visitors carried away a deep impression of the vitality of Hungarian physiology and biochemistry.

Joseph Needham
Dorothy M. Needham

CROSSED LAMELLAR STRUCTURE IN HIGHER PLANTS

A. B. WARDROP has directed attention to the existence of crossed lamellar structures in the cell walls of higher plants, such structures having hitherto been known with certainty to occur in some green algæ (*Australian J. Bot.*, **2**, 2, 154; 1954). When a number of higher plants in which it was considered that this structure might be present were examined, it was demonstrated in the phloem fibres of *Vinca major* and the tracheidal elements of the aerial root of *Alstonia spathulata*. In the latter, two types of crossed structure are recognized: in one, bands of laterally associated micro-fibrils *c.* 0·5 μ wide intersect at variable angles, whereas, in the other, lateral association is complete, forming a crossed lamellar structure which approaches most nearly that occurring in the algæ. In the outer layer of the secondary wall of wood fibres of *Eucalyptus elaeophora* and *E. regnans* there is inconclusive evidence of a crossed structure similar to that observed in the cell walls of some vessels, which consists of a loosely formed meshwork of aggregates of microfibrils. This structure is considered to be distinct from the crossed lamellar and cross-banded structures. The paper is illustrated by a number of electron micrographs.

The same author has also reported on the mechanism of the surface growth involved in the differentiation of fibres and tracheids (*ibid.*, p. 165). An electron microscopic investigation was made of the differentiating xylem elements of *Pinus radiata*, *Eucalyptus elaeophora* and *Ulmus* sp. In the tips of fibres and tracheids there is a tendency for the microfibrils of cellulose to be oriented in the direction of growth. It is considered that this orientation can be disturbed by subsequent dimensional changes in the cell. The thin areas of the differentiating cells which are involved in the so-called 'mosaic growth' have been compared with the regions of the cell wall penetrated by plasmodesmata in the storage parenchyma of potato tubers. The suggestion is made that the thin areas are regions of the cell wall penetrated by plasmodesmata, or are developing primary pit fields. The implications of this concept, with respect to intercellular readjustment and to the differences between fibres and tracheids in extension growth, are discussed.

FORESTRY IN JAMAICA

ANNUAL REPORT FOR 1952–53

IN the annual report of the Forest Department of Jamaica for the year ending March 1953*, allusion is made to the devastation caused by the great hurricane of 1951 and the rehabilitation work, forestry and planting carried out in 1952. Jamaica's forest policy is outlined in the report as follows: protection and development of the Island's natural forest resources, that is, existing forest reserves and future extension thereof; afforestation of suitable accessible areas with the view of increasing timber production and eventually making the Island self-supporting; encouragement of afforestation and sound forest management on private lands; and research work on sylvicultural and utilization problems.

It is obvious that considerable progress has been made by the Department, as a working plan for the production reserves has been drawn up and is being worked. It provides for three working circles—plantation, improvement and natural forest. The provisions are very similar to the earlier type of working plans drawn up in India and Burma during the latter part of the nineteenth century. However, there is a serious trouble, one which was also experienced in parts of India during the early days of the Department there. The general position regarding forest reserve boundaries, says the Conservator of Forests, continues to deteriorate and is directly attributable to land hunger of an ever-increasing population. Villagers deliberately remove the boundary stones and, when prosecuted, challenge the accuracy of the original survey, thus requiring a new survey to be made. The policy of the Department is

* Forest Department, Kingston, Jamaica, B.W.I. Annual Report for the Year ended 31st March, 1953. Pp. 12. (Kingston, Jamaica: Forest Department, 1953.)

naturally to give up any suitable land for agriculture, but such sites are now unfortunately very few and far between.

Artificial regeneration has been making considerable strides. The most popular species is mahoe (*Hibiscus elatus*); but the use of *Pinus patula* and *Eucalyptus saligna* has again been partly increased and formed approximately one-third of the area of 620 acres planted during the year. The total area of plantations formed by the Department amounts to 6,348 acres. The general planting programme has now a fairly constant pattern: above 3,000 ft. *Pinus patula* is planted on the grassland areas and *Eucalyptus saligna* on the old cultivation areas; in the middle-elevation areas, mahoe and broadleaf (*Terminalia latifolia*) are put on the sites of better soil and *Eucalyptus* species, *Pinus patula* and *Grevillea robusta* on the impoverished sites; in the coastal region mahoe is used in the drier localities and teak on alluvial flats.

INDUSTRIAL RESEARCH ASSOCIATIONS IN GREAT BRITAIN

ADDRESSING a meeting of the Parliamentary and Scientific Committee on July 13, Mr. G. L. Bailey, immediate past chairman of the Committee of Directors of Research Associations, said that the total income of the forty-one research associations in Britain to-day amounts to about £4·5 million, of which about £3 million comes from industry. The general object of the research associations is to encourage the use of scientific knowledge by industry, including both the acquisition of scientific knowledge and its application. More money is spent on research than on its application, and in his address Mr. Bailey concerned himself mainly with what is done to secure the application of research results in industry, although he instanced the work by Dr. A. J. P. Martin and Dr. R. L. M. Synge on partition chromatography and the new anti-corrosive composition formulated by the British Iron and Steel Research Association as outstanding examples of important achievements in pure research that are to the credit of a research association; the former arose out of a search for methods of analysis suitable for elucidating the chemical composition of wool, and the latter from a long-range detailed study of the corrosion of steel and its prevention.

Much of the research programme of the associations, said Mr. Bailey, is concerned with the development of new materials for a particular purpose or of new processes, and there are also smaller investigations and those relating to methods of testing or evaluation. Apart from the issue of reports or of scientific papers, the associations usually spend 15–20 per cent of their liaison service income on consultations originating in a direct approach from a member firm or arising out of a visit by a liaison officer for a general discussion. Such liaison work, moreover, is now tending to intensify application work at the expense of long-range research generally.

Dr. S. Whitehead, the chairman of the Committee of Directors of Research Associations, who followed Mr. Bailey, referred first to co-operation with universities and technical colleges, to which institutions the research associations make grants amounting to about £80,000 annually, their policy being usually to seek to interest universities in the inadequately explored portions of fundamental science on which industries are based. The research associations also bear much of the responsibility for scientific representation of their industries abroad, and government departments make great use of them on specialized projects. Mostly Dr. Whitehead's address was concerned with the question of development. Apart from their success in persuading individual members to undertake development, the research associations have sought to foster the group method of sharing the cost of development. During and since the Second World War the Government has successfully used the method of research or development contracts, and research associations have also found the National Research Development Corporation very helpful. The Coal Utilization and the Electrical Research Associations and the Shirley Institute, however, have also formed development companies, and this has two main advantages: the negotiation of commercial agreements and the technical problems of commercial application require a different type of staff and management; and, apart from some convenience over taxation, the development company hopes to make profits, and its finances can be more easily kept separate from that of its non-profit-making parent. Shirley Developments, Ltd., is concentrating at first on the commercial development and exploitation of instruments, devices and machines developed at the Shirley Institute, whereas Electrical Research Association Patents, Ltd., has largely confined itself to the granting of licences on important patents. Dr. Whitehead claimed that the research associations are at least as good as the best industrial research departments in the number of projects exploited, and that they are actively pursuing all the methods by which scientific discovery can be most rapidly, generally and fruitfully applied.

At the meeting, Sir Reginald Rootes limited his remarks to research in the motor industry, on the basis of which he maintained that the Motor Industry Research Association has fostered co-operation and done much to enable the British industry to keep abreast of its competitors; it provides buildings, research equipment and facilities on its proving-ground that are more comprehensive than those which individual manufacturers could afford. He also stressed the importance of adequate financial reserves and of research associations being able to plan their work for some years ahead.

SUB-GRAIN BOUNDARY CORROSION IN HIGH-PURITY ALUMINIUM

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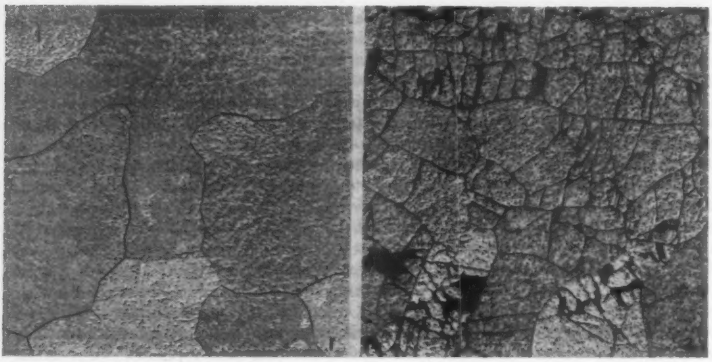
PREVIOUS observations of the intergranular corrosion of high-purity aluminium in hydrochloric acid have involved the general high-angle grain boundaries, and only superficial attack of the low-angle and sub-grain boundaries has been noted, except after prolonged anodic treatment[1]. We have observed that the sub-grain boundaries (as well as the low-angle grain boundaries) of properly heat-treated specimens are particularly susceptible to



Figs. 1 and 2. Effect of quenching-rate on attack of the sub-grain and low-angle grain boundaries after four days in solution. Annealing temperature 600° C.: (1) rapid water quench; (2) inefficient quench obtained by sealing the specimen in a glass tube and quenching in liquid nitrogen. (× 8)

corrosion in 7 per cent hydrochloric acid containing about 0·5 part per million of copper (added as cupric chloride). The attack noted after several days exposure is deep and selective, so that entire sub-grains become undermined and fall out of the specimen (Fig. 2). Although the corrosion of the sub-boundaries in this solution is still somewhat slower than that of the high-angle grain boundaries and increases in a general way with increasing orientation difference, the behaviour is distinctly different from that observed when the metallic impurity content of the acid is low; in this case, the acid strength must be increased to 20 per cent to obtain comparable rates of corrosion for high-angle boundaries (penetrations of order 1 mm. a week) and the relative dependence of the susceptibility to corrosion on orientation is then very strong[1] regardless of the heat treatment[2], and the sub-grain boundaries are only superficially attacked even after prolonged exposure.

Corrosion of sub-grain boundaries in 7 per cent hydrochloric acid containing 0·5 p.p.m. copper has been observed so far in aluminium ranging in purity from 99·97 to 99·996 per cent. The susceptibility to corrosion is dependent on heat treatment; it is minimized by a rapid quench and favoured by an inefficient quench from the annealing temperature. The latter was conveniently achieved by sealing the specimen in a glass tube and quenching in liquid nitrogen. The strong influence of heat treatment is illustrated in Figs. 1 and 2. In this lot of 99·98 per cent aluminium, annealing of the material as supplied (hard-rolled) produced large grains in which the principal sub-structure was coarse and easily observed. In specimens such as that shown in Fig. 2, the small-angle boundaries that are attacked after proper heat treatment correspond to orientation differences from several degrees to at least as low as 10 min.

The variation of the susceptibility of sub-boundaries to corrosion with the rate of cooling from the annealing temperature is presumed to involve the tendency of certain impurity (that is, solute) atoms to concentrate near these boundaries, as postulated by Lacombe and Berghezan[3] for the susceptibility to etching of sub-boundaries in aluminium–zinc alloys produced by ageing air-cooled specimens at room temperature. An appreciable concentration of solute atoms adjacent to the sub-boundaries cannot be produced in material of relatively high purity cooled from a high temperature at a relatively high rate unless these atoms are strongly attracted. The attraction of a solute atom to the region adjacent to a sub-boundary that can result from a difference of atomic size and an interaction with the stress field of the edge components of the dislocations composing the sub-boundary does not appear to be sufficiently great, as estimated from the treatment of Cottrell[4] for an isolated edge dislocation, to account by itself for the observed effects. It is hoped that further study of the influence of composition and heat treatment will provide additional information on this point.

The 7 per cent hydrochloric acid corroding agent containing copper is valuable as an etch fluid for revealing the sub-structure of properly heat-treated specimens. We have made some observations of sub-structures produced by bending single crystals or coarse-grained specimens (prepared by the strain-recrystallization method) and annealing at high temperatures. In general, boundaries running in all directions are observed even where constraints due to neighbouring grains are absent. An example is given in Fig. 3. This shows the sub-boundaries produced in two grains of a coarse-grained specimen, in which the lower grain covers the width of the specimen, together with the subdivided Laue spot obtained in a back-reflexion photograph taken in the lower grain. The axis of bending is parallel to the bottom edge of the figure. When the principal sub-boundaries run more or less parallel to the axis of bending, as in the lower grain, the difference of orientation across a sub-boundary is roughly as expected from the bend radius and the mean spacing of the sub-boundaries.

To date, it has been verified by X-ray measurements that boundaries where the difference of orientation is as small as 5 min. are susceptible to corrosion in this solution; this does not appear to be the lower limit. Corrosion of sub-boundaries in a generally similar manner has been obtained by substituting 100 p.p.m. iron for the copper added to the acid and also by anodic treatment (similar to that used by Lacombe and Yannaquis[1]) in 7 per cent

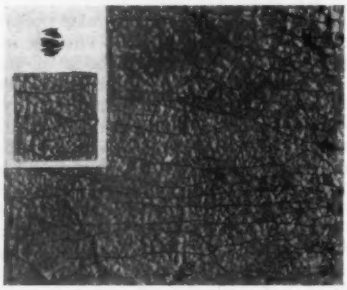


Fig. 3. Sub-boundaries in two grains revealed after four days in solution. Convex surface of coarse-grained sheet bent to a 20-cm. radius at room temperature and annealed at 645° C. The grain boundary is indicated by arrows. (× 8.) Inset shows a back-reflexion Laue spot (× 1½) together with the region of the lower grain (× 8) in which the X-ray photograph was taken. Specimen to film distance, 9 cm.; diameter of irradiated area, 1·5 mm.

hydrochloric acid without additions at current densities in the neighbourhood of 10 m.amp./dm.². With these methods also, the sub-boundaries are strongly attacked only after the proper heat treatment. The minimum difference of orientation, however, is slightly larger than is required when acid with added copper is used as the corroding agent. All these methods are capable of revealing boundaries for which the difference in orientation is smaller than that at which the aqua regia plus hydrofluoric acid etch fluid[5,6] is effective. By using several of the available techniques, it is possible to obtain some information concerning the magnitudes of the differences of orientation at the various sub-boundaries of a specimen. [April 29.

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[2] Metzger, M., and Intrater, J., "Intergranular Corrosion of High-Purity Aluminum in Hydrochloric Acid" (to be issued by the National Advisory Committee for Aeronautics).
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[6] Gervais, A. M., Norton, J. T., and Grant, N. J., *J. Met.*, **5**, 1166 (1953).

STRUCTURES OF MOLECULES AND CRYSTALS OF FLUORO-CARBONS

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POLYTETRAFLUOROETHYLENE[1] appears to be a chain polymer $(—CF_2—)_p$ of very high molecular weight, of the order of half a million[2]. The powdered material, as produced in the polymerization reaction, is highly crystalline below 20° C. The 'melting point'—the first-order transition from a partly crystalline to a completely amorphous structure—is about 330° C.[3,4], very much higher than that of the corresponding hydrocarbon polymer—132° C.[5], 136·5° C.[6]; but at 20° C. the fluorocarbon polymer shows another first-order transition involving a 1 per cent change of density, which is shown by X-ray diffraction patterns[4] to be due to a partial disordering of the crystalline regions. The occurrence of a reversible first-order transition involving disordering at a temperature so far below the 'melting point' (actually about half the absolute 'melting point') is unique among polymers, and directs increased attention to the structure of the molecules and of the crystals, both below and above the 20° C. transition.

It is also interesting that on closer examination the room-temperature transition has been found to be composite: although most of the change of density occurs at 20° C., there is an additional smaller change at 30° C.[7,8].

X-ray diffraction photographs of drawn fibres show that below 20° C. (Fig. 1*a*) the pattern is a typical 'fibre diagram' of a crystalline polymer in which the crystals are oriented with the chain direction of the molecules approximately parallel to the direction of drawing. The chain repeat-distance, calculated from layer-line spacings, is 16·8 A.; equatorial reflexions fit a pseudo-hexagonal projected cell-base with $a = b = 5{\cdot}54$ A. and $\gamma = 119{\cdot}5°$. The other unit cell parameters are still in doubt; but the general features of the diffraction pattern give very definite indications of the molecular configuration. The distance 5·54 A. and the very great strength of the 100 reflexion indicate a simple packing of rod-like molecules. A fully extended chain of singly linked carbon atoms has a plane zigzag character (as in polythene[9] and many other chain molecules); but in the fluorocarbon polymer the long-chain repeat-distance indicates some departure from a simple plane zigzag. The essential zigzag character is, however, revealed by the very strong near-meridian reflexions on the 6th and 7th layer lines, which indicate a sub-period between one-sixth and one-seventh of the true period, namely, $16{\cdot}8/6{\cdot}5 = 2{\cdot}6$ A., which is about the span of one zigzag of a carbon chain. That there are indeed $6\frac{1}{2}$ zigzags in the chain repeat is confirmed by diffraction photographs taken with the fibre axis oscillating at appropriate angles to the X-ray beam; such photographs show one, and only one, reflexion from a plane perpendicular to the chain axis, and this (an extremely strong one) has a Bragg spacing of 1·294 A., one-thirteenth of the full chain repeat. The fact that there is only one such reflexion indicates that the CF_2 groups are equally spaced along the chain, and this suggests a regular helix; and the (at first sight) curious number of $6\frac{1}{2}$ zigzags in the repeating unit receives a simple explanation if we imagine a plane zigzag twisted 180° in 16·8 A. or 13 chain atoms. A full 360° twist of the chain occurs in 33·6 A., 13 zigzags or 26 chain atoms, but the actual period is half this, because a zigzag consists of two lines of atoms, and a half twist brings the fourteenth atom on the second line directly above the first atom on the first line (Fig. 2). There are other ways of describing this helix; thus successive carbon atoms lie on a helix of six turns in 16·8 A.; but the first description (of the twisted zigzag) is stereochemically the most appropriate, as it refers to the bond structure.

Confirmation of this 13-atom helix is indicated by a group of fairly strong reflexions near the equator, on the second layer, with spacings 2·0–2·4 A., from planes inclined 15–20° to the chain axis; fluorine atoms attached to such a helical carbon chain fall approximately on planes having this spacing and orientation—in other words, the molecular transform has a maximum in this region.

Calculations of layer-line intensities for various types of helical (twisted zigzag) chains, made by the Bessel function method[2,3], show that the helix described above is the only one which will account for the observed intensities, and give the radius of the fluorine helix as 1·64 A. (± 0·05) and that of the carbon helix as approximately 0·42 A.

When the temperature is raised to 25° C., the diffraction pattern changes profoundly (Fig. 1*b*): equatorial reflexions, and those on the 6th and 7th layer lines, remain sharp (in fact, become actually sharper); but all those on intermediate layer lines become very diffuse, groups of reflexions being converted into broad areas of diffuse scattering. This last fact—that the areas of diffuse scattering are in the same places as previous groups of sharp reflexions—shows that the molecular configuration is unchanged; and this is confirmed by the spacing of the 13th order of the chain period, which remains precisely the same as it was below 20° C. (1·294 A.). We have found no evidence of an increase of chain period reported by others[10]. The disordering, therefore, affects only the positions of the molecules, not their configuration. The lateral spacings are slightly

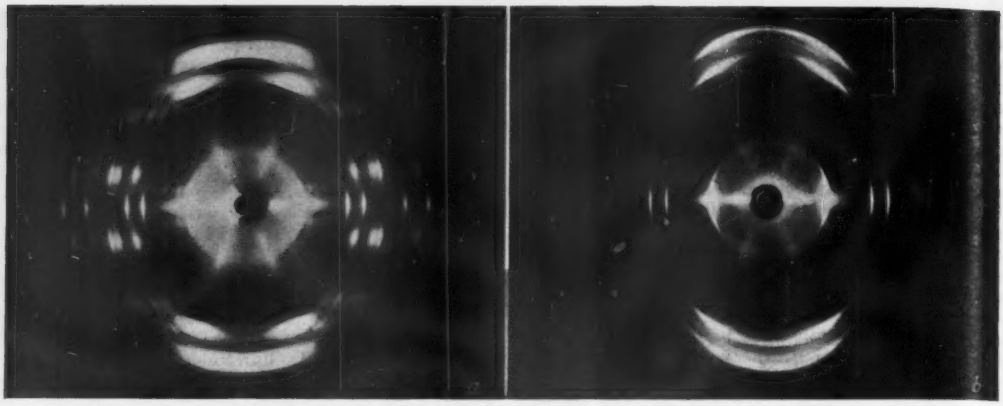

Fig. 1. X-Ray diffraction photographs of polytetrafluoroethylene: (*a*) at 10° C.; (*b*) at 25° C.

increased (the projected cell-base is hexagonal with $a = 5{\cdot}61$ A. and $\gamma = 120°$), but the sharpness of the equatorial reflexions shows that the side-by-side packing is highly regular. The disorder must therefore consist of a variable displacement of the molecules along their chain axes, or a variable rotation about their chain axes. The fact that the 6th and 7th layer-line reflexions are sharp shows that any longitudinal displacement can only be in steps equal to the zigzag span. Variable rotation about the chain axes without longitudinal displacement would, of course, keep all the CF_2 groups on the same levels, and ensure the sharpness of the 6th and 7th layer reflexions. It does not appear to be possible to distinguish between the two alternative types of disorder, which in the polymer lead to precisely the same semi-disordered crystal structure.

At 35° C. (that is, above the subsidiary transition at 30° C.) the equatorial reflexions remain sharp, but the 6th and 7th layer reflexions become diffuse or disappear; this means that CF_2 groups are no longer on exactly the same levels. The molecular interpretation of the two transitions suggested by these facts is therefore that the main 20° C. transition is due either to rotation around the chain axes or longitudinal displacement in precise steps equal to the zigzag span, while the subsidiary 30° C. transition is due to longitudinal displacements which are not in precise steps. Up to 150° C. the strong 6th and 7th layer reflexions become more and more diffuse as the temperature rises, while the equatorial reflexions remain sharp; evidently the longitudinal displacements become more and more random.

Crystals of perfluorocetane, $C_{16}F_{34}$, which are flakes of hexagonal outline, have been examined by the same methods. A crystal rotated around the normal to the flake gives, at room temperature, an X-ray diffraction pattern which is strikingly similar to that of the high-polymer fibre well above 30° C.: there are sharp equatorial reflexions which fit a hexagonal projected cell-base, and elsewhere, very diffuse scattering having the same pattern as in the high polymer. Evidently the molecules have essentially the same helical configuration as those of the high polymer. The pattern differs from that of the high polymer, however, in showing meridian reflexions which are successive orders of a spacing of 23·1 A., representing the limited length of the molecules. Oscillation photographs show that the higher orders of this chain spacing are appreciably broadened; there is evidently some disorder in the direction of the chain axes.

The diffraction pattern changes to the sharp pattern of an ordinary fully-ordered crystal only at very low temperatures: the transition temperature is about −170° C. The behaviour of this fluorocarbon is thus similar to that of the high polymer, except that the transition temperature is even lower (at less than one-third the absolute melting point). It may eventually be possible, from the X-ray diffraction patterns of perfluorocetane, to distinguish between rotations and translations of the molecules in the crystals.

Two very interesting questions arise from these conclusions. In the first place, why is it that the fluorocarbon molecules have a helical chain with a

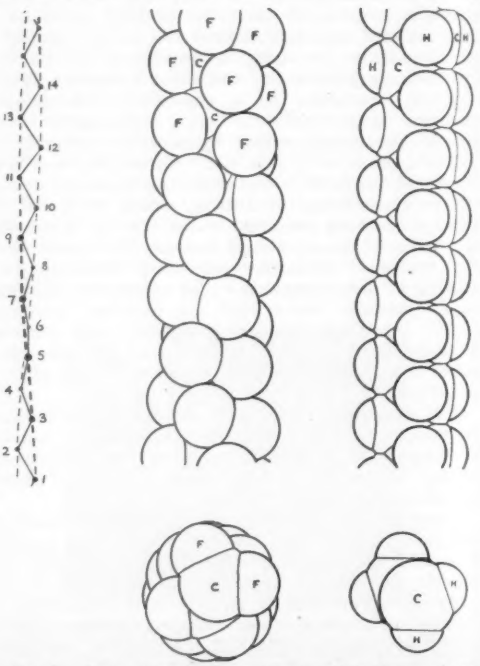

Fig. 2. Left: twisted zigzag chain found in fluorocarbons. Centre: fluorocarbon molecule (side and end views). Right: hydrocarbon molecule

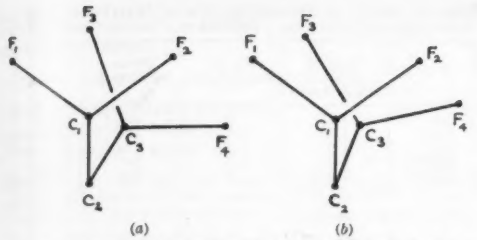

Fig. 3. (*a*) Configuration giving equal F—F distances ($F_1F_3 = F_2F_4$); (*b*) configuration actually found

13-atom repeating unit, while the corresponding hydrocarbon molecules have a plane zigzag carbon chain? And secondly, why are fluorocarbon crystals disordered so far below their melting points?

In the plane zigzag chain found in the hydrocarbons[9], the span of the zigzag is 2·539 A. Hydrogen atoms attached to next-but-one carbon atoms are also at this distance from each other. Since the van der Waals radius of hydrogen is 1·1–1·2 A., there is ample room for these atoms—in fact, they are not in contact but separated by a gap (see Fig. 2); but the van der Waals radius of fluorine is 1·35 A.; double this figure is 2·70 A., so that fluorine atoms attached to a plane zigzag carbon chain would be overcrowded. The helical structure is presumably due to rotation around the chain-bonds which takes place to increase the distance between the fluorine atoms. It is interesting to find, however, that although satisfactory distances between fluorine atoms could be attained by a rotation which would bring one fluorine atom (F_3 in Fig. 3*a*) equidistant from the two (F_1 and F_2) on the next-but-one carbon atom, this is not what actually happens; instead, a smaller rotation occurs (giving unequal F—F distances), and the remainder of the required increase of the shortest distance is provided by an increase of the zigzag span from 2·539 A. (the figure for hydrocarbons) to 2·595 A., an increase which is presumably due to an opening of the bond angle (to 116°), since this is much easier than stretching the C—C bonds. The limitation of the rotation may be due to repulsion between fluorine atoms and next-but-one chain carbon atoms (F_3 and C_1 in Fig. 3*b*) or to a bond-orientation effect (as distinct from atom repulsions) which favours staggered configurations of which the plane zigzag chain is the simplest example[11].

The order–disorder transition which occurs at room temperature in the high polymer is evidently not a phenomenon peculiar to the polymer, for the same type of transition is found in perfluorocetane, again at a temperature far below the absolute melting point; it is evidently due to some feature of the structure of a fluorocarbon chain. The transition may be analogous to the change that occurs[12] in paraffin hydrocarbons from C_{21} to C_{27} (but not in the high polymer[13]) a few degrees below the melting point, a change that is thought to be due to the onset of rotation of the molecules about their long axes (though the only evidence is the change to hexagonal symmetry). In the fluorocarbons we have much more definite evidence for disorder, and, above all, the transition occurs far below the melting point. Molecular models show that the fluorocarbon chain is more 'streamlined' than the hydrocarbon chain (see Fig. 2) in the sense that the general shape is more nearly cylindrical and the projections and depressions in the profile are smaller in relation to the cross-sectional area of the molecule. The close approach to cylindrical shape may be the simple explanation of the existence of disordered crystals at such low temperatures. Both rotations around the chain axis and longitudinal translations would be facilitated by such a streamlined shape.

Many crystals composed of molecules of approximately spherical or cylindrical shape suffer transitions which appear to be due to the onset of molecular rotation[14–20]. For some spherical molecules (camphor and certain derivatives) and flat cylindrical molecules, the transition temperature is far below the melting point[14,16]; but for long-chain molecules (aliphatic hydrocarbons, acids and alcohols) molecular rotation usually occurs (if at all) only a few degrees below the melting point[12,18]. The fluorocarbons are quite exceptional among chain compounds in showing evidence of disorder very far below their melting points. The controlling factor is probably the size of the projections and depressions in the profile, in relation to the diameter of the molecule: camphor and its derivatives have a predominantly hydrocarbon surface, characterized by projections and depressions of similar size to those in chain hydrocarbons, but owing to the greater diameter of the cage-like camphor molecule, the projections and depressions are relatively smaller. Among slender chain molecules it is only the fluorocarbon surface which is sufficiently smooth to permit rotation at very low temperatures.

Polytetrafluoroethylene has other exceptional properties; in particular, its coefficient of friction is remarkably low—much lower than that of polythene—and indeed it appears to be unique among plastics in this respect[21,22]. It seems possible that this also is connected with the disorder transition at room temperature, and is in fact due to the same feature of the molecular structure—the smooth profile of the molecule, which permits easy slip of one molecule past another and easy gliding on the crystal planes which are parallel to the chain axes.

We wish to thank Dr. R. N. Haszeldine for providing a specimen of perfluorocetane. [July 12.

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LETTERS TO THE EDITORS

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Pentamethonium as an Adjuvant to Atropine in the Therapy of Paraoxon Poisoning

Paton and Perry[1] demonstrated a competitive antagonism between acetyl choline and pentamethyline *bis*-trimethyl ammonium dibromide (pentamethonium), at ganglia, and this suggested that pentamethonium might be of value in treating poisoning with anticholinesterases such as diethyl 4-nitrophenyl phosphate (paraoxon). Douglas and Matthews[2] used pentamethonium in cats poisoned with tetraethyl pyrophosphate (TEPP), and showed that it improved the contractile power of the diaphragm. We now have evidence that pentamethonium bromide significantly increases survival of fully atropinized animals—mice, rabbits and cats—poisoned with paraoxon.

Table 2. Effect of Pentamethonium on Survival of Cats and Rabbits

	Dose of paraoxon (mgm./kgm.)	No. of experiments	Pentamethonium	Result
Cat	1·75	3	No	Died
Cat	1·75	3	Yes	Recovered
Cat	2·0	2	Yes	Recovered
Rabbit	1·0	3	No	Died
Rabbit	1·0	3	Yes	Recovered

In mice a quantitative expression of the therapeutic potency of pentamethonium was obtained by plotting dose-effect curves for the intravenous injection of: (1) paraoxon alone, (2) paraoxon plus various doses of atropine, and (3) paraoxon plus a full dose of atropine (10 mgm./kgm.) plus pentamethonium. The LD50 value for each treatment was calculated by the probit method and these, along with their 95 per cent fiducial limits and the slopes, are given in Table 1. For the test with pentamethonium, a dose of 10 mgm./kgm. of atropine was selected. This was not the optimum of the doses of atropine tested; but the difference in protection afforded by 5, 10, 20 and 30 mgm./kgm. of atropine was insignificant. Adding pentamethonium to the atropine increased the LD50 over the highest figure obtained with atropine alone 2½ times. As the protective action improved, the slope of the regression line became flatter, and when pentamethonium was injected, survival occurred in a high proportion of mice given more than 4 mgm./kgm. of paraoxon.

Experiments with rabbits and cats anæsthetized with a chloralose – urethane mixture gave similar results. Sufficient paraoxon was injected into these animals to cause severe respiratory depression in spite of a full dose of atropine given simultaneously. To some nothing more was given, and these all died within thirty minutes. To others additional atropine was given intravenously, and these too died. To others again pentamethonium was given intravenously and these all recovered within the limits of an acute experiment (see Table 2).

An explanation of the beneficial effect of pentamethonium in these two species was forthcoming in the shape of an immediate increase in the respiratory volume. Its effect on the blood pressure, as is well known, was to lower it; but following an initial fall, a slow but steady rise set in. The respiratory volume, on the other hand, rose steeply in all experiments, reaching a peak within one minute of the injection. A limited fall then took place, and it was not until 15–20 min. later that it began to rise again.

Fig. 1 shows the respiratory volume in three typical experiments with the cat, plotted as a percentage of the average volume measured for 30 min.

Table 1. LD50 Values for Female Mice given Intravenous Injections of Paraoxon Alone and Together with Antagonists

Treatment	No. of mice injected	LD50 paraoxon (mgm./kgm.)	95 per cent fiducial limits	Slope
Paraoxon alone	101	0·48	0·46–0·49	22·54 ± 3·43
" + 1 mgm./kgm. atropine	55	0·56	0·55–0·57	44·74 ± 8·25
" + 5 " "	122	0·87	0·82–0·91	11·90 ± 1·92
" + 10 " "	110	0·89	0·82–0·97	7·78 ± 1·63
" + 20 " "	50	1·00	0·88–1·13	7·51 ± 1·82
" + 30 " "	60	0·94	0·86–1·03	10·23 ± 2·58
" + 10 " " + 10 mgm./kgm. pentamethonium	130	2·28	1·86–2·80	2·62 ± 0·47

or more before injection of the drugs. The same initial dose of paraoxon and atropine was given to all three, and the effect on the respiratory volume of injecting pentamethonium or further atropine can be compared with that of no treatment at all. It will be seen that further atropine, so far from im-

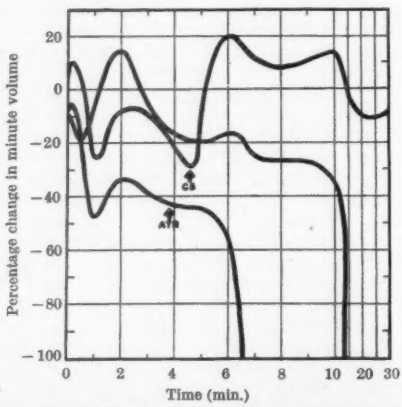

Fig. 1. Effect of pentamethonium on the respiratory minute volume of the cat. In all three experiments paraoxon (1·75 mgm./kgm.) together with atropine sulphate (2·0 mgm./kgm.) was injected intravenously at zero time. The arrows denote the time at which pentamethonium bromide (C5) (10 mgm./kgm.) was injected intravenously in one experiment, and atropine sulphate (2·0 mgm./kgm.) in another

proving the animal's condition, actually precipitated respiratory arrest.

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M. K. McPhail

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Excretion in Human Urine of an Unknown Amino-acid derived from Dates

In the course of an investigation with the aid of paper chromatography of the genetics of amino-acid excretion in man, it was observed that some individuals excreted large quantities of an unknown ninhydrin-positive substance. Upon inquiry concerning the diet of these individuals, it was found that dates had been eaten in all cases. Seven individuals were selected who had not eaten dates for at least a month, and chromatograms of their urine were prepared. In no case was the 'date spot' observed. These seven individuals were then fed eight to ten dates in the evening, and the following morning a sample of their urine was collected. Another urine sample was obtained the following morning. In every case the chromatograms of the first urine specimen showed quite clearly the 'date spot'. The chromatograms of the urine specimens produced on the second day after eating dates showed only a trace of this spot, or failed to show it altogether.

The unknown substance which produces the 'date spot' moves on the two-dimensional chromatograms in phenol–lutidine solvents to a location almost identical with that of α-amino-*n*-butyric acid. However, in butanol–acetic (4 : 1 : 1) solvent, this substance moves much less than α-amino-*n*-butyric acid, its R_F being about 0·25. The colour of the spot after developing with ninhydrin and heating also differentiates it from α-amino-*n*-butyric acid. The 'date spot' is clear blue, resembling somewhat the colour given on similar chromatograms by aspartic acid, rather than the violet or purple given by most other amino-acids. This blue becomes gradually more purple after standing for several days.

We have also investigated the occurrence of this substance in the date, and find that it is present in the free form and does not appear to increase in amount after acid hydrolysis. This suggests that the substance is an amino-acid and not a peptide. A copper complex test has also been run indicating that the substance is an α-amino-acid.

It is interesting that the amino-acid under consideration is excreted apparently unchanged, since from superficial appearances its excretion appears to be quantitative. This is a rather unusual situation for amino-acid metabolism in the human body; but we have no positive proof that the excretion is strictly quantitative.

This work was carried out by one of us (S. G.) during the tenure of a U.S. Public Health Service postdoctoral fellowship.

Stanley Gartler
Th. Dobzhansky

Institute for the Study of Human Variation,
Columbia University,
New York City. June 8.

A Peculiar Nutritional Dermatitis in Pigs

In the course of our advisory duties, we have frequently encountered a number of cases of a peculiar dermatitis in pigs. The condition develops in pigs of about 10–12 weeks of age and is characterized initially by the development of red blotches under the skin of the hocks, spreading up the hind legs into the groin and over the belly and eventually over the back and ears. The dermatitis is accompanied by an acute irritation; the pigs become very uncomfortable and rub continually against the sides of the sties. This rubbing usually breaks the skin, resulting in the formation of extensive scabs. Appetite is adversely affected and the pigs make little or no liveweight gain. Natural recovery is very slow, and as a result of the condition, the pigs may take several weeks longer to reach the bacon factory.

The condition develops on both home-mixed and proprietary rations, with or without added antibiotics, and cannot be controlled by normal oily or powder dressings, dipping, bathing or spraying with insecticide preparations. It has only been found when pigs are dry-fed, even though drinking water is freely available.

The dermatitis can be quickly controlled and finally obviated by changing the affected pigs to wet-feeding. The inclusion of fodder beet or potatoes in the diet results in a marked improvement; but the recovery is not so dramatic as that which occurs when a wet-feeding practice is employed. On wet-feeding, appetite is quickly regained, the scabs slowly disappear and the pigs begin to put on weight again.

There is as yet no evidence of the fundamental cause of the condition or a valid explanation of the mechanism of the empirical cure; but we are putting these observations on record in the hope that they will be of value to others who may have encountered the condition, which would appear to be of more widespread occurrence than has hitherto been recognized.

Thanks are due to Col. J. E. B. Freeman, Buxhall Vale, Stowmarket, for allowing us facilities for experiments and for his careful observations.

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National Agricultural Advisory Service,
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Action of Squalene upon Carcinogenic Hydrocarbons

Squalene is an unsaturated triterpenoid hydrocarbon which was originally isolated from the liver oil of the shark[1]. Among its other occurrences, it was found to be present in the fat from ovarian dermoid cysts[2]. In an investigation on the role of sebum in carcinogenesis, squalene was found to be present in horse smegma and in human ear wax and hair oil[3,4]. MacKenna and co-workers found it in skin surface sebum[5].

The possible role of squalene as a protective agent in sebum is under investigation in this laboratory. It has already been shown to be fungistatic *in vitro* against certain dermatophytes[6]. This appears to be related to rapid peroxide formation which occurs when squalene is exposed to air.

Squalene was purified by passage through alumina. 3-Methylcholanthrene, 7,12-dimethylbenz[*a*]anthra-

cene and benzo[*a*]pyrene (from Eastman Organic Chemicals) were purified before use. 100-mgm. samples of freshly purified squalene containing 500 μgm. of carcinogen were exposed at 37° C. in 35 c.c. round-bottomed centrifuge bottles. After the desired time interval, 10 c.c. of methanol was added and then 3 c.c. of cold 1 *N* sodium hydroxide. The mixture was then extracted six times with 5-c.c. portions of petroleum ether. The solvent was removed by evaporation under reduced pressure. Aliquots were taken for fluorometric determination of the hydrocarbon content and for squalene determination[4].

This procedure permitted a quantitative recovery of squalene and each of the hydrocarbons when the extraction procedure was carried out immediately. Complete, or nearly complete, recovery of the hydrocarbons was obtained when mineral oil replaced squalene and the period of exposure at 37° C. was as long as one month.

Only 7 per cent of 7,12-dimethylbenz[*a*]anthracene could be recovered after exposure to squalene for one week at 37° C. Nothing could be recovered after the second week. In the case of 3-methylcholanthrene 30 per cent remained after the first week and only traces were found afterwards. The possible presence of a fluorescence-quenching substance was ruled out. On the other hand, even after five weeks of exposure, 92 per cent of benzo[*a*]pyrene was recoverable. This substance exerted a profound antioxidant activity, for squalene could still be recovered in nearly theoretical amounts. During this period squalene alone was almost completely oxidized. 7,12-Dimethylbenz[*a*]anthracene exerted almost no antioxidant effect although 3-methylcholanthrene was somewhat inhibitory.

Bernheim *et al.*[7] demonstrated that carcinogens inhibit fatty-acid oxidation in the epidermis of the mouse and suggest that carcinogens, by inhibiting peroxide formation, may produce conditions favourable for growth. The observation with benzo[*a*]pyrene is in conformity with the suggestion of these workers. Mueller *et al.*[8] reported some time ago that benzo[*a*]pyrene and 3-methylcholanthrene are destroyed in oxidizing unsaturated fatty acids. It remains to be seen whether the products of the reaction of 3-methylcholanthrene and 7,12-dimethylbenz[*a*]anthracene with squalene are still carcinogenic and whether this reaction is related to the role of squalene in sebum.

This project was supported by Grant *C*-2012 of the National Cancer Institute, U.S. Public Health Service.

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Cortisone in Relation to Infection and Tumour Growth

Nicol, Helmy and Abou-Zikry[1] showed that œstrogens stimulate the reticulo-endothelial macrophages in the spleen, liver, and lymph nodes, and that prolonged œstrogen treatment or stimulation by large doses of œstrogen appears to lead to mobilization of the macrophages in these organs. The reticulo-endothelial system is an important defence mechanism against malignant tumours in general[2,3], and its stimulation therefore probably increases the general defence of the body against tumour growth.

In view of the recent reports that patients being treated with cortisone are more susceptible to infection, and that cortisone enhances the spread of transplanted tumours in animals, it seemed desirable to study the effect of this hormone on the reticulo-endothelial system.

Seventeen male guinea pigs aged about one year were used for the present investigation. The reticulo-endothelial macrophages were studied by giving all the animals one daily injection of trypan blue subcutaneously for the last six days prior to being killed by chloroform. The dosage of the dye was calculated on the basis of 0·8 ml. of a 1 per cent solution in distilled water per 100 gm. body-weight. Seven of the animals were given dye only and were used as controls. The ten remaining animals each received 5–10 mgm. of cortisone (Roussel Laboratories, Ltd.) intramuscularly once daily for one to four weeks in addition to the dye. Specimens were taken from the spleen, liver and lymph nodes and fixed in Heidenhain's 'Susa' fluid. Sections were cut at 10 μ thick and stained with dilute carbol-fuchsin or weak eosin. The activity of the reticulo-endothelial system in the organs studied was measured by the number of dye-bearing cells and the intensity of the vital staining.

The results are as follows. In two of the four animals which received 5 mgm. of cortisone once daily for seven days, the intensity of the vital staining was reduced in the macrophages of the spleen compared with the results in the controls; but no appreciable effect was observed in the macrophages of the liver and lymph nodes. In the remaining animals which received 5 mgm. of cortisone daily for seven days, then 10 mgm. for a further two to three weeks, the reduced intensity of the vital staining in the macrophages of the spleen was still more marked; in those which received hormone treatment for four weeks, the vital staining was also slightly reduced in the macrophages of the liver and lymph nodes.

These preliminary results show that cortisone depresses the activity of the reticulo-endothelial macrophages especially in the spleen, and in this manner probably lowers the defence of the body against infection and new growths.

For this research we gratefully acknowledge the gift of cortisone by the Medical Research Council.

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Chemotherapeutic Experiments with Natural Constituents of the Body

Borsook and co-workers[1], from redox potential measurements, claimed in 1935 to have found that dehydroascorbic acid and reduced glutathione can form an intermediate compound *in vitro* from which ascorbic acid can be regenerated. The occurrence of this reaction in living organisms was contested by Bersin and others[2], who considered that the formation of ascorbic acid from dehydroascorbic acid was effected by an enzyme. Neither the supposed intermediate compound nor the enzyme has so far been actually shown to exist.

The fact that ascorbic acid itself has a bactericidal action was shown by von Gagyi[3] and myself[4]. Cysteine has been used in the treatment of hepatitis and also in the treatment of mustard gas burns of the skin; for which latter purpose I devised[5] an electrophoretic method. As is well known, mustard gas burns in their clinical course strongly resemble X-ray injuries, and cysteine has also been used for the treatment of injuries of this kind. Presumably the effect is due to detoxication of toxic substances resulting from the irradiation. In the same way cysteine has been used for diminishing the toxic effects of nitrogen mustard when this is employed in cancer therapy[6].

The results referred to above seem to indicate the probability of a chemotherapeutic activity of cysteine and ascorbic acid, and for this reason as early as 1939 a compound of cysteine and ascorbic acid was prepared by me under the direction of Prof. Hans Schmalfuss.

Synthesis of cysteylascorbic acid. 0·02 mol. dried cysteine hydrochloride (Merck) was warmed at 40° for 30 min. with 12 ml. of carefully purified thionyl chloride and the mixture then shaken at room temperature for 4 hr. The acid chloride was then removed by filtration and the product washed with purified acetyl chloride and light petroleum (boiling point 49°) in an atmosphere of nitrogen. The product was added with stirring and in an atmosphere of nitrogen to a suspension of very pure 0·02 mol. sodium ascorbate dried in 300 ml. of thoroughly dried absolute alcohol; the stirring was continued for 4 hr. The undissolved residue was filtered off, and the solution kept overnight in the ice-chest under nitrogen. Next day a small precipitate was removed by filtration and the solution concentrated in a stream of nitrogen at 20 mm. until turbidity appeared; dry ether was added until precipitation of solid was complete; the precipitate is the chemotherapeutically active substance.

For chemical investigation attempts were made to purify the compound by two recrystallizations from alcohol. This purification has so far only been partly successful. The recrystallized compound forms rhombic crystals of questionable disintegration point 157° (found: C, 35·7; H, 4·71; N, 4·9 per cent. $C_9H_{13}O_7NS,H_2O$ requires C, 36·6; H, 5·1; N, 4·7 per cent). The absorption curve in the ultra-violet gave a maximum at 255 mμ in absolute alcohol. Pure ascorbic acid shows a maximum at 245 mμ.

More precise details must await further experiments on the constitution of the compound. By far the most effective compound in bacteriological experiments was finally prepared with a modification of the above-mentioned synthesis, which is referred to later on.

Chemotherapeutic experiments. As experimental animals young mice weighing about 6 gm. were used. The bacterial strains employed were highly virulent, virulence having been increased by five passages through mice.

Since the chemotherapeutic action might also be exercised by a mixture of ascorbic acid and cysteine, the following mixtures and individual substances were studied for their action on intraperitoneal pneumococcal infections of the mouse: (1) an equimolecular mixture of cysteine hydrochloride and sodium ascorbate; (2) the residue obtained by evaporating to dryness an aqueous solution of an equimolecular mixture of cysteine hydrochloride and sodium ascorbate; (3) the same product stirred with light petroleum for several hours; (4) cysteine hydrochloride; (5) the first insoluble residue obtained during the synthesis of cysteylascorbic acid; (6) the residue obtained by evaporating the final solution after precipitation of the cysteylascorbic acid with ether.

Infection was induced by intraperitoneal injection of 0·3 ml. of undiluted culture of *Pneumococcus mucosus*; the various substances to be tested were dissolved in 0·2 ml. saline and injected immediately or within 30 min. of the time of the inoculation. For each experiment two experimental animals and two controls were used. The results are shown in Table 1.

Table 1

Substance No.	50 mgm.	25 mgm.	6·25 mgm.	12·5 mgm.	3 mgm.	Control
1	– –	+ +	+ +	+ +	+ +	+ +
2	– –	– –	+ +	– –	– –	+ +
3	– –	– –	+ +	– –	– –	+ +
4	– –	+ +	+ +	+ +	+ +	+ +
5	+ +	+ +	+ +	+ +	+ +	+ +
6	+ +	+ +	+ +	+ +	+ +	+ +

+ indicates death

At the same time, and by the same technique, an experiment was carried out with the cysteylascorbic acid, the results of which are shown in Table 2.

Table 2

Experiment No.	30 mgm.	12 mgm.	8 mgm.	4 mgm.	2 mgm.	1 mgm.	Control
1	*LL*	*LL*	*LL*	*LL*	*LL*	*LL*	+ +
2	*LL*	*LL*	*LL*	*LL*	*LL*	*LL*	+ +

L = survived

In a further experiment, groups of four mice were inoculated with 30,000 lethal doses of another strain of pneumococcus and treated similarly with the cysteylascorbic acid at different dose-levels with the results shown in Table 3.

Table 3

Experiment No.	20 mgm.	15 mgm.	10 mgm.	5 mgm.	Control
3	*LLLL*	*LLLL*	*LLLL*	+ +*L*+	+ + + +

Finally, groups of three mice were treated with 10 mgm. of cysteylascorbic acid 1½, 3 and 4½ hr. after inoculation. All treated animals survived; the four controls died after 12 hr. In all the experiments with pneumococcal infection taken together, 107 control animals died, mostly within 12 hr., and 45 treated animals survived.

In vitro, the cysteinylascorbic acid inhibited the growth of the pneumococcus employed down to a concentration of 450 μgm. per ml. as compared with inhibitory concentrations of aureomycin and streptomycin of 25–250 μgm. per ml.

Experiments with Staph. aureus, Strep. pyogenes haemolyticus and Esch. coli. Similar chemotherapeutic

experiments were carried out with mice infected with two lethal doses of a virulent strain of *Staph. aureus*. Survival of all animals was obtained with doses of cysteinylascorbic acid as low as 0·075 mgm., and again, as in the case of the pneumococcus infection, doses of 10 mgm. of the compound given 1½, 3 and 4½ hr. after inoculation were sufficient to protect mice against heavy doses of the organism. The strain of *Staph. aureus* employed was resistant to penicillin, aureomycin and streptomycin.

Preliminary experiments with *Streptococcus* and *Esch. coli* indicate a similar degree of chemotherapeutic activity. Most of the bacteriological experiments were carried out by the director of the Bacteriological Department, Dr. Hans Lodenkämper, with the assistance of Dr. Stienen, Lohmühlenkrankenhaus, Hamburg. I myself was responsible for the first bacteriological experiments.

Summary. The experiments described above leave no doubt concerning the chemotherapeutic activity of the cysteylascorbic acid, although this compound has not yet been prepared in a completely pure state. Since the experiments reveal a new principle, namely, the possibility of the chemotherapeutic employment of natural constituents of the body, it is considered desirable to publish the observations although the chemical constitution of the compound is not yet certainly established.

The ultra-violet absorption spectrum and polarographic analysis of the compound make it likely that it is a cysteyl ester of ascorbic acid, the attachment of the cysteine residue being at C_2 or C_3. The yield of the compound obtained by the method described is 15–20 per cent. Possible alternative synthetic methods for its preparation are now being studied. The toxicity of the compound for mice is negligible since a dose of 3 gm./kgm. is tolerated without ill-effect. The effect could probably be explained through the formation of a complex compound of the cysteine with the copper of the serum and certain copper-containing ferments of bacteria. The copper is, according to Heilmeyer and Keiderling[7], much increased after infections, whereas the iron is diminished.

It seems possible that the compound may find a use in diminishing the toxicity of nitrogen mustard and in preventing injury from X-irradiation; experiments to test these points are in view.

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Secretion of Juvenile Hormone by the Corpus Allatum of *Calliphora*

It is now generally accepted that metamorphosis in insects is prevented throughout the larval stages by the secretion of the 'juvenile hormone' by the corpus allatum; but this has never been quite satisfactorily proved in the Diptera. Vogt[1] obtained some evidence that the corpus allatum restrains the development of the imaginal disks in the early stages of *Drosophila*. She also showed[2] that the corpus allatum of young *Drosophila* larvæ would induce yolk formation in adult *Drosophila* deprived of the corpus allatum; and since the yolk-forming hormone is the same as the juvenile hormone[3], this finding suggests that the hormone is present in the *Drosophila* larva. Vogt[4] and Possompès[5] also obtained evidence that the corpus allatum of the adult *Drosophila* and *Calliphora* will cause partial and local inhibition in the formation of pupal or adult cuticle.

The problem has been re-investigated by implanting the corpus allatum of *Calliphora* into the abdomen of the fifth-stage larva of *Rhodnius* fed one day previously. Implantation of the corpus allatum (together with the corpus cardiacum) from adult *Calliphora* of either sex, fed on sugar alone or on sugar and meat, resulted in several instances (three out of twenty survivals) in the appearance of a small localized patch of larval cuticle in the resulting adult.

The ring gland together with the central nervous system from second-stage larvæ of *Calliphora*, or the isolated dorsal region of the ring gland of small third-stage larvæ of *Calliphora*, were similarly implanted. Out of fifty-one adult *Rhodnius* surviving, six showed patches of cuticle with more or less well-marked larval characters over the site of the implant. Fig. 1 illustrates one of these patches overlying the implant of the dorsal part of the ring gland of a third-stage *Calliphora* larva.

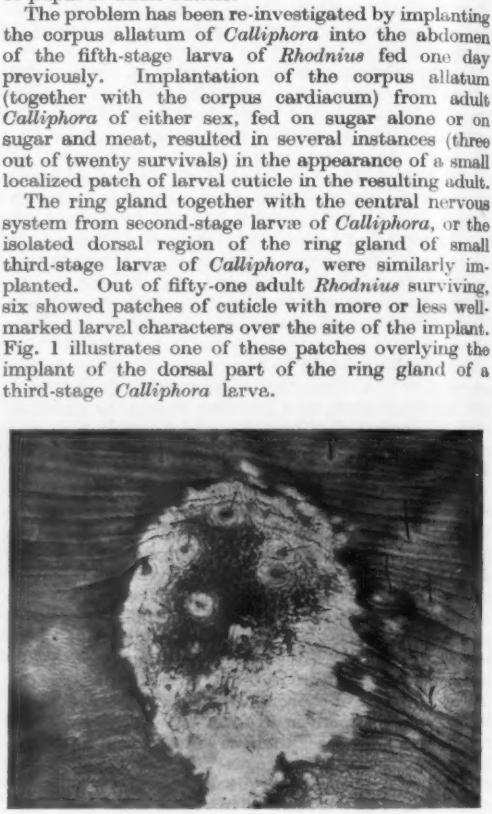

Fig. 1. Part of an abdominal tergite in *Rhodnius* adult with a patch of larval cuticle, showing bristle-bearing plaques and characteristic folding of the epicuticle, overlying an implanted ring gland from a third-stage *Calliphora* larva. The pale patch is just 0·5 mm. wide

These results not only prove the existence of the juvenile hormone in Diptera, but also they provide further evidence of the non-specific character of this hormone.

I am indebted to Mr. P. J. Judge for supplying *Calliphora* larvæ reared under sterile conditions.

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Submerged Culture Production of Diphtheria Toxin

It has been shown[1-3] that high-titre diphtheria toxin can be produced by growing the Park Williams No. 8 strain of *C. diphtheriae* in shaking flasks, and one of us[4] has reported the production of 100 Lf. u./ml. toxins in stirred and aerated cultures. Recently, using the latter technique, we have been able to prepare high-titre toxins (Lf. 150–200 u./ml.) by growing the organism for 48 hr. in 14-litre amounts of tryptic digest medium[1] in 20-litre 'Pyrex' flasks stirred by either a glass or a 'Birmabright' (a magnesium–aluminium alloy) stirrer with air bubbling through the cultures from an 'Aerox' filter (porosity *P* 28) at the rate of one-sixth litre of air per litre of medium per minute. Such culture filtrates contain 1,500–1,700 Lf./mgm. protein nitrogen and are, therefore, very suitable starting material for the further purification of the diphtheria toxin. Moreover, the antigen composition of the culture filtrates, concentrated by ultrafiltration, when examined by a gel diffusion test against antitoxin[5], was found to be as complex as in surface-culture filtrates; but the amounts of the contaminating antigens were less, thus explaining the higher purities obtained from submerged cultures.

Further experiments using glass-lined vessels stirred with aluminium 'vortex' stirrers of a type similar to that suggested by Chain[6], with air being passed over the surface of the medium and not through a bubbler or sparger ring, have also given as good results as those obtained with 'Pyrex' glass flasks. Experiments with culture vessels constructed of commercial aluminium have given quite high titre toxins, but such vessels show signs of attack by the culture on continued use, accompanied by a decrease in toxin production. This problem is now under investigation.

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Blood Platelets as Carriers of Adrenaline and Noradrenaline

It is now widely accepted that, provided the sympathetic innervation is intact, adrenaline is discharged continuously from the suprarenal medulla, even under basal conditions. Several authors[1] found a basal discharge of 0·03–0·06 μgm./kgm./min. from the two suprarenals of cats and dogs. According to our results[2], the adrenaline arteriovenous difference in man is about 0·5 μgm./l. of blood, which corresponds, as a first approximation, to a rate of utilization of about 0·03 μgm./kgm./min.—a value in good agreement with the established rate of adrenaline discharge.

An arteriovenous difference of 0·5 μgm./l. is compatible with the figures which we find for the concentration of adrenaline in venous plasma, namely, 1·0–1·6 μgm./l. of blood[3]. The validity of the method used has been checked by paper-chromatographic studies which showed that the material estimated could be recovered from the expected positions in yields approximating to those of model experiments, and that the fluorescence developed in the eluates had the expected spectral properties[2].

However, Holzbauer and Vogt[4], on the basis of a biological method, recently came to the conclusion that the adrenaline content of plasma is much lower. They also found that insulin injection increased the plasma adrenaline concentration, whereas we had found the opposite effect[5].

It occurred to us that these discrepancies might be explained, at least in part, by the different methods of blood collection. Holzbauer and Vogt, conforming to the exigencies of the biological method, took every precaution to prevent platelet breakdown, whereas in our method[6] the blood is collected in a hypertonic solution and in untreated glassware, conditions known to lead to the disintegration of the blood platelets. 209 ml. blood was collected in a silicone-coated cylinder containing 3,500 units of heparin dissolved in 1·5 ml. isotonic sodium chloride; 15 ml. was withdrawn and mixed with 5 ml. of a sodium fluoride – sodium thiosulphate solution[6] for estimation by method of Weil-Malherbe and Bone[3], the remainder centrifuged in silicone-coated tubes at ~ 600 *g* for 20 min. Plasma (72 ml.) was separated and half of it recentrifuged at ~ 3,000 *g* for 20 min. Both plasma fractions, and the residue from the second spin, were transferred to untreated glassware and mixed with the sodium fluoride – sodium thiosulphate solution and acetate buffer, prior to chromatography on alumina columns[6]. The eluates from the two plasma fractions were each divided into four parts: one part for estimation by the ethylenediamine method[3] and three parts for estimation according to Lund[7] (one part each for oxidation at *p*H 3·0, oxidation at *p*H 6·5 and for the blank).

It appears from the results shown in Tables 1 and 2 that the substances estimated as adrenaline and noradrenaline by our method are indeed associated, to a large extent, with the blood platelets. When platelet disintegration is avoided, about 70–80 per cent may be removed from plasma by centrifuging and a considerable part may be recovered from the platelet residue.

Table 1. Estimation of Adrenaline and Noradrenaline (μgm./l. blood) in 'Platelet-rich' and 'Platelet-poor' Plasma

	Assay by ethylenediamine method (ref. 3)		Assay by Lund's method (ref. 7)	
	Adren.	Noradren.	Adren.	Noradren.
Blood collected in NaF–$Na_2S_2O_3$ solution	1·46	3·70	1·56*	5·40*
Blood collected in heparin and siliconized glass:				
Plasma spun at ~600 *g*	1·47	4·25	2·37	2·96
Plasma spun at ~3,000 *g*	0·34	1·20	0·36	1·17
Residue from second spin	0·72	2·11		

* These values were determined on a different blood sample collected from the same subject some days previously.

Table 2. Effect of Fractional Centrifugation on Plasma Content of Adrenaline and Noradrenaline

Blood (54 ml.) collected in heparin and siliconized glass. Plasma (24 ml.) divided into three parts and two parts re-centrifuged at ~ 3,000 *g* and 12,000 *g*, respectively. Estimation by ethylenediamine method (ref. 3)

	Adrenaline (μgm./l. blood)	Noradrenaline (μgm./l. blood)
Plasma spun at ~ 600 *g*	1·24	5·56
Plasma spun at ~ 3,000 *g*	0·64	3·44
Plasma spun at ~ 12,000 *g*	0·31	1·56

It is also shown in Table 1 that Lund's method[7] gives, in our hands, results which are very similar to those obtained by the ethylenediamine method[3]. The fact that the same result is obtained with two independent chemical methods, both having a high degree of specificity, surely is yet another strong argument in favour of the substances estimated being identical with adrenaline and noradrenaline.

The fraction previously regarded as 'plasma' adrenaline undergoes rapid and extensive changes in response to the injection of various hormones and drugs, to convulsions and to changes in the level of consciousness (natural sleep). In contrast to the adrenaline content of the red blood corpuscles, which is not significantly affected by these stimuli, the adrenaline store of the platelets appears to have important physiological functions. The platelets are already known to harbour histamine, at least in the rabbit[8], and 5-hydroxytryptamine[9]. They thus emerge as a store-house of circulating pharmacologically active amines.

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Vitamin B_{12} in Crude Liver Extracts

In a previous communication[1], we reported that when cyanocobalamin was added to certain crude liver extracts, assays carried out by means of a mutant of *Escherichia coli* gave much lower results than would have been expected from the amount of vitamin B_{12} added, although *Lactobacillus leichmannii* gave fairly satisfactory recoveries. It was suggested that such extracts contained a substance that interfered with the utilization of vitamin B_{12} by *E. coli*. We have since obtained additional results on the nature of this interfering factor, and the publication of two recent papers[2,3] on the presence of bound forms of vitamin B_{12} in human serum and in sow's milk respectively prompts us to put our preliminary results on record.

In the first of these papers, Pitney *et al.*[2] reported that in the assay of human serum for vitamin B_{12} by means of *Euglena gracilis* higher values were obtained after the serum had been heated (confirming an earlier observation by Ross[4]), and that when vitamin B_{12} was added to the serum not more than 50 per cent could be accounted for on subsequent assay. From electrophoretic experiments it was concluded that the α-globulin fraction of human serum was able to bind vitamin B_{12}, forming a complex which did not stimulate the growth of *E. gracilis*.

In the second paper, Gregory and Holdsworth[3] reported the isolation from sow's milk of a protein which formed with cyanocobalamin a complex that did not stimulate the growth of *L. leichmannii*; after digestion with trypsin or papain some stimulation of growth occurred, and this was enhanced after the enzymic digest had been heated. Sow's milk not only contains vitamin B_{12} in bound form but also is capable of binding considerable amounts of added cyanocobalamin.

We have obtained evidence that some of the vitamin B_{12} in crude liver extracts cannot be assayed by means of the *E. coli* mutant, and have also observed binding of cyanocobalamin by crude liver extracts analogous to that recorded by Pitney *et al.* and Gregory and Holdsworth; but there are important differences in the nature of the complex formed. We have shown, for example (using for assay the *E. coli* mutant and not *L. leichmannii* or *E. gracilis*), that the apparent vitamin B_{12} content of these liver extracts increases on boiling and that only a proportion of added cyanocobalamin can be accounted for when using *E. coli* for assay. It was observed, however, that the 15-min. boiling found to be adequate by Pitney *et al.* was insufficient to liberate the bound vitamin in our liver extracts, heating for 4 hr. being optimal. Another striking difference between the behaviour of blood serum and liver extract towards vitamin B_{12} is that whereas Pitney *et al.* imply that liberation of vitamin B_{12} takes place as the result of denaturation of the protein to which it is bound, so that binding is presumably irreversible, we have found that when a crude liver extract is allowed to stand for some days after having been boiled, the apparent vitamin B_{12} content falls to the original value.

Our results suggest to us that crude liver extracts contain a vitamin B_{12}-binding substance, and that the vitamin B_{12} in such extracts is to some extent present in bound form, as has already been postulated by other workers[5,6]; but we believe that the binding is not due to the formation of a complex with a protein as has been suggested, although the possibility that vitamin B_{12} is bound to a peptide of low molecular weight cannot be excluded. We have found, for example, contrary to the observations of other workers[5,6] that the microbiological activity of our extracts is not increased by treatment with cyanide; secondly, that the bound vitamin B_{12} can be dialysed, although slowly, through a 'Cellophane' membrane; and thirdly, that the activity of the extracts is not increased by digestion with papain or trypsin, although pancreatin significantly enhances the activity.

We have also compared the behaviour of vitamin B_{12} in liver extracts with the behaviour of cyanocobalamin in presence of an intrinsic factor concentrate made from hog's stomach by the method of Prusoff *et al.*[8]. The two types of binding appear to be quite different. In the first place, there was no increase in activity as measured by *E. coli* after the solution had been boiled as occurred with liver extracts; and secondly, it has been reported that vitamin B_{12} is not dialysed through a 'Cellophane' membrane in presence of intrinsic factor, in contrast

to the behaviour of the bound vitamin B_{12} in liver extracts.

Wijmenga *et al.*[5] have pointed out that no method of isolating cyanocobalamin from liver extracts has been described that does not involve a proteolytic step, and that when Smith[9,10] originally described the isolation of vitamin B_{12} he reported that two pink bands were formed on partition chromatography, one of which appeared to be transformed into the other on treatment with a proteolytic enzyme. Cooley *et al.*[6] have suggested that vitamin B_{12} may be present in liver in the form of a cobalichrome in which the cyano group is replaced by a protein or polypeptide moiety. That this may be partially true is suggested by the fact that we have invariably found less cyanocobalamin in liver extracts by the chemical method of Boxer and Rickards[11] than by microbiological assay, unless the liver extract has first been subjected to cyanide treatment, when the agreement between the two sets of results is fairly good. This confirms Boxer and Rickards's conclusion that "in liver concentrates, cyanocobalamin usually accounts for only a small fraction of total cobalamins".

By contrast, the cyano group is apparently unaffected when intrinsic factor is added to cyanocobalamin, since the results obtained with such a mixture by the method of Boxer and Rickards was in good agreement with the amount of cyanocobalamin present. This supports the observation of Wijmenga *et al.*[12], based on a study of absorption spectra, that the cyano group is still present in the cyanocobalamin-intrinsic factor complex.

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A Riboflavin-producing Bacterium

Riboflavin synthesis has been demonstrated in a wide variety of micro-organisms by means of growth studies; these have been adequately reviewed from time to time[1]. Among the bacteria, members of various genera have been reported to produce riboflavin in very small amounts[2], and none has been reported which exceeds the capacity of *Cl. acetobutylicum* to produce this vitamin.

During the course of routine work, an air-contaminant was found to produce an intense greenish-yellow pigment in a medium consisting of casein hydrolysate and beef-extract. This pigment appears to be riboflavin; the compound, like the vitamin, has the following properties: (*a*) it exhibits an intense greenish-yellow fluorescence in ultra-violet light; (*b*) the fluorescence is instantaneously discharged on the addition of sodium hydrosulphite; (*c*) it has absorption maxima at 225, 269, 372 and 445 mμ, as measured in the Beckman spectrophotometer.

The air contaminant was found to be a bacterium. It was isolated in the pure state by the usual methods. On microscopic examination it was found to be coccoid, arranged in irregular groups of sizes 0·8–1·0 μ in diameter. It is Gram-negative (observed after 6 hr., 12 hr., 24 hr. and 48 hr.).

The amount of riboflavin produced by this organism was determined by carrying out static and agitated fermentations, using a medium containing casein hydrolysate and beef-extract. Riboflavin production was assayed by the fluorimetric method using a pure riboflavin solution as the standard and found to be of the order of 150–250 μgm./ml., the maximum amount being produced in the reciprocating shaker at 26° C., the yield obtained being 250 μgm./ml. This high yield of riboflavin by a bacterium is very interesting and further studies on the identification of the organism are in progress.

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Inhibition of D-Amino-acid Oxidase

Peptides containing D-amino-acids are not attacked by D-amino-acid oxidase[1,2]. We have found that the action of pig kidney D-amino-acid oxidase on DL-leucine was inhibited by DL-leucinamide, DL-leucylglycine, DL-leucylglycylglycine, and by glycyl-DL-leucine. These compounds also inhibited the enzymic oxidation of DL-valine and DL-phenylalanine. Thus, DL-leucinamide when added to DL-leucine, DL-valine or DL-phenylalanine in a molar ratio 5 : 1 inhibited the oxidation by 35–45 per cent. DL-Leucylglycine inhibited the oxidation of DL-leucine by 40–45 per cent, of DL-phenylalanine by 50 per cent, and of DL-valine by 60 per cent. DL-Leucylglycylglycine inhibited the oxidation of DL-phenylalanine by 25 per cent, of DL-leucine by 30 per cent, and of DL-valine by 65 per cent. Glycyl-DL-leucine gave similar results. With glycylglycine no inhibition was obtained.

It was also found that derivatives of DL-valine, DL-leucine and DL-phenylalanine in which one of the amino-hydrogens was substituted by ethyl, hydroxyethyl or cyclohexyl radicals also acted as inhibitors of D-amino-acid oxidase. Thus, DL-N-ethylphenylalanine inhibited the oxidation of DL-phenylalanine

by 70 per cent; DL-N-ethylleucine that of DL-leucine by 80 per cent; DL-N-hydroxyethylvaline that of DL-valine by 80 per cent; and DL-N-cyclohexylvaline that of DL-valine by 65 per cent. It was found in some cases that derivatives of one amino-acid inhibited the oxidation of other amino-acids more than that of the parent compound. For example, DL-N-ethylvaline inhibited the oxidation of DL-leucine by 45 per cent, whereas the oxidation of DL-valine was inhibited by 15 per cent only.

The oxidative deaminations of DL-valine, DL-leucine and DL-phenylalanine were also 23–30 per cent inhibited by DL-N-ethylleucylglycine.

The experiments were carried out in a Warburg apparatus at 38° by the usual technique. The *p*H varied between 8·1 and 8·5 (pyrophosphate buffer, 0·06 *M*). Aqueous extracts (usually 1 ml. per reaction mixture) of acetone-dried pig kidney preparations were used[1]. The final concentration of the DL-amino-acids was 0·008 *M* and that of the derivatives 0·04 *M*. The total volume of the reaction mixture was 2·5 ml. Oxygen uptake was measured after 60 min.

None of the amino-acid derivatives mentioned above was attacked by the enzyme to any significant extent.

It is known that the effects of crude enzyme preparations as used by us are the results of the combined activities of D-amino-acid oxidase proper and catalase[2]. The apparent inhibitions described above might therefore represent an increase in the rate of catalase action rather than an inhibition of the oxidase. We therefore tested the action of our enzyme extracts on hydrogen peroxide in separate experiments. The addition of either DL-N-ethyl-leucine, DL-leucinamide, DL-leucylglycylglycine or glycyl-DL-leucine had no influence on the catalase activity measured. Hence it may be concluded that the effects of the various compounds here described represent a true inhibition of D-amino-acid oxidase.

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Hydrolysis of Methylglucosides

In the course of a study of the mechanisms involved in the solvolytic reactions of glycosides, we have investigated the position of bond fission occurring in the hydrolysis of α- and β-D-methylglucosides. The reactions were carried out in water enriched in oxygen-18, and the methanol produced was isolated by fractional distillation in an efficient column, and then pyrolysed to give carbon monoxide which was examined by a mass spectrometer. We have found that the hydrolysis of α- and β-D-methylglucosides both in 1 *N* acid solution and in the presence of appropriate methylglucosidases proceeds by fission of the hexose–oxygen bond:

$$R|\text{—O—CH}_3 + \text{H}_2\,{}^{18}\text{O} \rightarrow R\text{—}{}^{18}\text{O—H} + \text{HOCH}_3$$

The results of typical experiments are shown in Table 1.

Table 1

Substrate	Catalyst	*p*H	Temp. (° C.)	Time of heating (hr.)	% excess abundance oxygen-18 in solution	% excess abundance oxygen-18 in methanol
α-D-Methyl-glucoside	1·10 *N* HCl	—	80	65	0·540	0·005
"	Yeast* α-methyl-glucosidase	6·5	35·7	6	0·300	0·000
β-D-Methyl-glucoside	1·10 *N* HCl	—	80	65	0·540	0·008
"	Almond emulsin	4·6	35·7	24	0·360	0·029
Blanks Glucose + methyl alcohol	1·10 *N* HCl	—	80	65	0·540	0·001
"	Yeast α-methyl-glucosidase	6·5	35·7	6	0·300	0·003
"	Almond emulsin	4·5	35·7	20	1·63	0·005

* A solution containing yeast α-methylglucosidase was obtained by killing, after washing and pressing, brewer's bottom yeast with liquid nitrogen and extracting the resultant autolysate with 0·1 *N* ammonia. Extracts prepared by autolysing the cells with toluene or ethyl acetate gave similar results.

Armstrong's[1] classical demonstration that α-D-glucose could be detected in the products of enzymolysis of α-D-methylglucoside, and that similarly β-D-glucose could arise from β-D-methylglucoside, has been used for relating the configurations of the glucosides to those of the parent sugars. The implicit assumption is, as Koshland[2] has pointed out, that no Walden inversion occurs. The present results show that since it is the hexose–oxygen bond which breaks, Armstrong's results cannot safely be used in this way. It can be said, however, that given the configurations on other grounds, Armstrong's work shows that under his conditions substitution at the $C_{(1)}$ atom occurs without a Walden inversion.

It is interesting to note that, both in the acid- and the enzyme-catalysed reactions, the position of bond fission is the same. The acid-catalysed reactions presumably proceed via the reversible formation of the conjugate acids of the glucoside followed either by rate-determining formation of a carbonium ion, with or without ring opening, or alternatively by bimolecular attack on the $C_{(1)}$ atom of the pyranose ring by a water molecule. The latter possibility, which seems unlikely on steric grounds, would, of course, involve a Walden inversion at the $C_{(1)}$ atom; but owing to the rapid mutarotation of the product under acid conditions, this test has no diagnostic value.

We are grateful to Profs. E. D. Hughes and C. K. Ingold for their help and encouragement. We are also indebted to Messrs. Barclay Perkins, Ltd., for a generous gift of brewer's bottom yeast.

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Effect of Oxygen on the Frequency of Chromosome Aberrations produced by 8-Ethoxycaffeine

Some years ago, Thoday and Read[1,2] discovered that the frequency of chromosome aberrations produced by X-rays in root tips of *Vicia faba* is dependent on oxygen tension during irradiation, while that produced by α-rays is not. Since then this discovery has been confirmed by several investigations, and a similar effect of oxygen was found also, when other tissues and organisms were used as experimental material (for references, see Giles[3] or Gray[4]). In the case of X-rays, therefore, it seems to be a general rule that much less chromosome damage of the physiological, as well as of the structural, type is obtained when the irradiations are performed in the absence than in the presence of oxygen.

At present, the generally accepted explanation of the oxygen effect is "that oxygen makes available certain radicals produced from the decomposition of water which would otherwise be lost"[4]. Thus the effect of oxygen indicates that chemical steps intervene between ionization and chromosome damage. Since hydrogen peroxide is produced in water by irradiation only if oxygen is present in the case of X-rays, but independently of oxygen tension in the case of α-rays, Thoday and Read[2] assumed "that hydrogen peroxide had some influence on the process involved in chromosome structural damage". Facts in favour of the peroxide hypothesis have been presented also by Fabergé[5] and Giles[3]. Current opinion, however, favours the view that, in the case of X-rays at least, the major part in chromosome damage is played by the hydroperoxyl radical (HO_2).

With this radiochemical explanation of the oxygen effect in mind, it would not be expected that oxygen could have any influence on the frequency of chromosome aberrations produced by radiomimetic chemicals.

In connexion with a comparative study of the effect of X-rays and the purine derivative 8-ethoxycaffeine on root tip chromosomes of *Allium cepa*, the influence of oxygen tension was also tested. The radiomimetic effect of this and other purine derivatives as well as the methods used have been described previously[6,7].

The onions were placed on tubes with their roots immersed in saturated aqueous solutions of 8-ethoxycaffeine (10^{-2} *M*) through which nitrogen or oxygen was bubbled. In order to minimize the back diffusion of air, the bulbs as well as the upper parts of the tubes were enclosed in plastic bags with small openings for the egress of the gases. Before treatment, the 8-ethoxycaffeine solutions were saturated with oxygen or nitrogen. In the first experiment performed, four onions were treated with 8-ethoxycaffeine for 1 hr., two in nitrogen and two in oxygen, while two were used as controls. Before the 8-ethoxycaffeine treatments, the roots were pretreated in water for 30 min. with the gases in question, and after the treatment the onions were kept in oxygen or nitrogen for 15 min. before they were transferred for recovery to tubes containing tap-water. The two controls were treated in tap-water with oxygen and nitrogen respectively for 105 min. The temperature during treatment and recovery was 18° C. Fixations in alcohol–acetic acid (3 : 1) were made 3/4, 4, 8 and 24 hr. after the 8-ethoxycaffeine treatments. Slides were prepared as Feulgen squashes.

The examinations of the slides revealed that 8-ethoxycaffeine is much more effective in producing chromosome aberrations in oxygen than in nitrogen. As in the case of X-rays[2,8], both the stickiness effect and the frequency of structural chromosome changes were influenced by the oxygen concentration during treatment. The stickiness effect in oxygen was very strong and could be observed as long as four hours after treatment. After an ordinary treatment (in air), the stickiness effect usually disappears within two hours. In nitrogen only a very slight stickiness effect was produced. Fig. 1 shows how the structural chromosome changes produced by 8-ethoxycaffeine are influenced by the oxygen concentration. The effect is scored as abnormal anaphases, that is, anaphases with fragments and bridges. In each case the effect is estimated on the bases of at least 50, usually 100, analysed anaphases. Although the variation between the two bulbs treated in oxygen is very great, particularly in the 4- and 8-hr. fixations, there can be no doubt about the significance of the difference between the effects obtained in oxygen on one hand and those obtained in nitrogen on the other. Eight hours after the treatment, the frequency of chromosome aberrations produced by 8-ethoxycaffeine is at a maximum. At the same time the mean effect in oxygen is more than six times greater than that in nitrogen. The only effect found in the controls (oxygen or nitrogen alone) was a somewhat higher frequency of mitosis in the oxygen control.

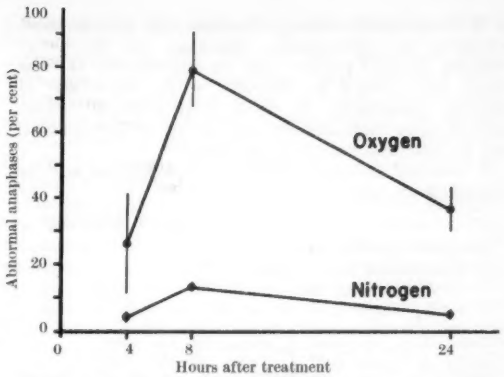

Fig. 1. Effect of 8-ethoxycaffeine in oxygen (upper curve) and in nitrogen (lower curve)

Because of the unexpected results obtained, the experiment was repeated. The experimental conditions were, however, altered in some respects. Thus the pretreatment with oxygen or nitrogen was reduced to 15 min., the 8-ethoxycaffeine treatment was reduced to 45 min., and the temperature during treatment and recovery was changed to 20° C. The results of this experiment were essentially the same as before: the effect produced by 8-ethoxycaffeine in oxygen was much greater than that in nitrogen. Thus the results indicate that the oxygen concentration influences the effect of 8-ethoxycaffeine on chromosomes similarly to the way in which it influences that of X-rays; the similarity seems, however, to be restricted to the production of chromosome aberrations. While the inhibition of mitosis by X-rays, according to Thoday and Read[2], is increased by oxygen, no such increase was observed in the case of 8-ethoxycaffeine.

Finally, it may be mentioned that, besides oxygen tension, the temperature during treatment also seems to influence the effect of X-rays and 8-ethoxycaffeine

in a very similar way. Further, the cell is most sensitive to chromosome breakage by 8-ethoxycaffeine in the second half of interphase, as was found for X-rays by Revell[9], while the stage of greatest sensitivity to di (2 : 3-epoxypropyl) ether, and to other radiomimetic chemicals so far studied, lies in the first half of interphase[9,10].

A detailed account of these investigations will be published elsewhere.

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A Second Virus Disease of the Leatherjacket, *Tipula paludosa*

In an earlier communication[1], a 'polyhedrosis' of apparently cancerous blood cells of *Tipula paludosa* larvæ was described. The cytoplasmic disease described here is primarily of the larval fat body. No multiplication of the fat cells is involved, and no inclusion bodies are formed as the result of the disease. A few animals with both diseases have been observed in addition to the many in which they occurred singly.

The intact infected animal may be recognized in strong sunlight, when the fat body appears purple through the wetted skin. In the course of the disease the lobules of the fat body distend enormously and the tissue becomes nodular. The nodules are orange in transmitted light and iridescent, purple, blue, green, etc., in reflected light. The animals, when moribund, become purplish-white in colour with the disruption of diseased fat cells and the liberation of their contents into the blood. Death occurs two to four weeks or more after the disease becomes detectable. As many as 15 per cent of a low-density natural population of *Tipula* larvæ were found to have the disease, which appears to be less virulent than the polyhedroses of lepidopterous larvæ.

The cytology of infected cells has been examined in whole mounts of fat tissue, both unfixed and fixed in osmic acid, alcohol and Carnoy's fluid, and in sections fixed in the last. Early in the course of the disease the cells lose their fat globules. While the infected cells are still only slightly enlarged, highly refractile cytoplasmic networks form which usually completely surround their nuclei. At this stage one or several small spots, orange in transmitted light, become visible in the cytoplasm. The fat body then becomes nodular owing to the enormous enlargement of the infected cells, the cytoplasms of which outside the networks, which are now also enlarged, become completely filled with this material, orange in transmitted light and iridescent in reflected light (Fig. 1).

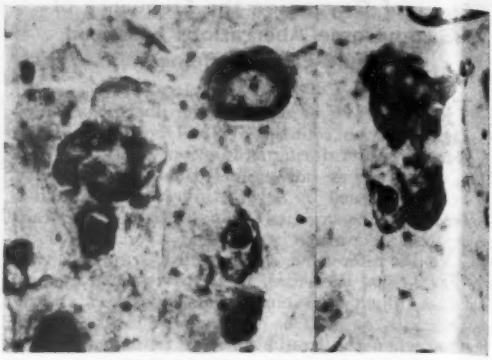

Fig. 1. Section of fat body cells of diseased larvæ of *Tipula paludosa* showing 'normal' nuclei, enlarged cytoplasm, and the peculiar cytoplasmic nets. × 900

The iridescence is readily visible even in 4-μ sections of fixed tissue.

The cytoplasmic nets of the infected cells are heavily loaded with ribose nucleic acid, and after acid hydrolysis lose their capacity to stain intensely with Giemsa fluid. They are Feulgen-negative. The cytoplasm of these cells stains only a pale blue wash with Giemsa; but after acid hydrolysis it stains an intense purple-red colour. It is intensely Feulgen-positive throughout. Sections, 4 μ or more in thickness, of Carnoy-fixed nodules swell markedly in glacial formic acid and in 1 *N* sodium hydroxide, and shrink again in water, properties which are shared by the untreated Feulgen-positive 'polyhedra' described previously[1]. The homogeneous unfixed cytoplasm swells in water and dilute alkalis and proceeds to break down to minute granules at the limits of visibility. By high-speed differential centrifugation of infected fat bodies disrupted and washed in water or 0·14 *M* sodium chloride, pellets of particles 100 mμ diameter may be obtained. These pellets are orange in transmitted light and iridescent in reflected light. After hydrolysis for 1 hr. in 1 *N* hydrochloric acid at 100° C., this material has a typical nucleic acid absorption spectrum with its peak at about 265 A.

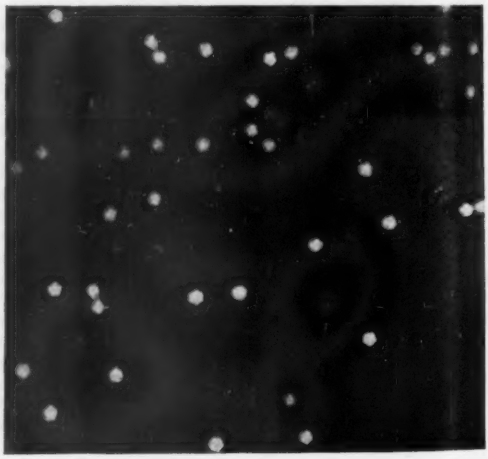

Fig. 2. Virus bodies prepared in distilled water. Shadowed with palladium. × *c.* 24,000. Electron micrograph by S. Vernon Smith

The evidence indicates that the particles contain deoxyribose nucleic acid. It is concluded that the 100-mμ particles (Fig. 2), with which the iridescence of the cytoplasm is associated, are the virus. The virus bodies are not simple spheres, but are somewhat irregular in shape and composite, many smaller particles being embedded in each. They thus resemble the viruses of the cytoplasmic polyhedroses of the midgut of lepidopterous larvæ[1,2], rather than the rod-shaped viruses of the nuclear polyhedroses.

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[1] Smith, Kenneth M., and Xeros, N., *Nature* **173**, 866 (1954).
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Factors affecting the Larval Spot Colours of the Emperor Moth, *Saturnia pavonia* L.

From time to time the variation in the colour of the spots of the larvæ of *Saturnia pavonia* has attracted attention. These spot colours do not develop until the fourth and fifth instars. The spots of any given larva are similarly coloured; but the colour itself may vary within the range of pale lemon-yellow through orange to pink. From the selective breeding experiments of Poulton[1], it was apparent that the colour differences between larvæ could not be attributed to a simple genetical basis.

I have observed that the spot colour of the individual larva changes progressively throughout the duration of the instar, being pale lemon-yellow immediately after the moult and generally orange or pink by the time of the next moult or ensuing pupation. This progressive colour change has been found not to be simply dependent on the larval age within the instar but to be primarily a response to the intensity of the light to which the larva is exposed throughout the instar, the spots of larvæ which are kept in the dark remaining yellow. With larvæ exposed to light the rate of the colour change is most rapid in the few hours immediately following the moult. Larvæ which have been kept in the dark for the first three days after the moult show little colour change when exposed to normal daylight for the remainder of the instar. The final spot colour of the fourth instar does not appear to influence the spot colour of the fifth instar.

Experiments have been carried out and are continuing on the relationship between the rate of response and the light intensity in order to determine the nature of the response and to ascertain if it depends on a trigger-type reaction. The response appears to be locally determined and is not dependent on light entering the ocelli. The actual colour change itself involves two major components, the change from yellow to orange occurring in the underlying epidermal cells while changes from yellow through orange to pink occur in the overlying cuticle.

Fuller details will be published later.

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Identity of *Gammarus tigrinus* Sexton 1939

Gammarus tigrinus Sexton[1] was described from saline waters in the Avon area, and has since been recorded from fresh and saline waters in several places in England and Ireland[2,3]. A map showing the known localities will appear in volume 12 of the *Proceedings* of the International Association of Theoretical and Applied Limnology.

Because it is unknown from other parts of Europe, and is closely related to the North American species *G. annulatus* Smith, Spooner[3] has suggested that it is probably a recent introduction from the New World. At the suggestion of Dr. S. G. Segerstråle, of Helsinki, I asked Dr. E. L. Bousfield, of the National Museum of Canada, if he could assist me in identifying the species. He informed me that he had long been of the opinion that it was the common North American freshwater and oligohaline brackish species *G. fasciatus* Say, which it resembles in being distinctly striped when alive—a character not shown by the brackish-water species *G. annulatus*. Comparison between specimens of *G. fasciatus* kindly sent to me by Dr. Bousfield and British specimens of *G. tigrinus* has fully confirmed this belief. The name *G. tigrinus* must therefore be superseded by *G. fasciatus*.

This species occurs widely in eastern North America, and is common in weedy places (Clemens[4]). In Great Britain it is also found in weedy places on muddy substrata, a type of habitat not favoured by any of the native species, although often colonized here by *Crangonyx gracilis* Smith, which is also of North American origin. In view of this, and of the importance of amphipods as food for fishes, *G. fasciatus* may well prove to be a useful animal for introduction into fish-ponds. At Wyken Slough, near Coventry, a muddy weedy lake, it would appear to be the main food organism for a large and varied population of coarse fishes.

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The Maximum of the Planck Energy Spectrum

The spectral distribution of energy radiated from a black body is well known to exhibit a maximum. For example, the thermal radiation from a 6,000-deg. black body (to which the sun approximates) is chiefly concentrated towards the visible wave-lengths and falls off in the infra-red and ultra-violet.

It is natural to inquire where this maximum falls, and Wien's law is usually called on to supply the answer. This law is often quoted in the form:

$$\lambda_m T = 0{\cdot}2897 \text{ cm. deg.},$$

where λ_m is the wave-length where the maximum falls and T is the temperature of the black body. (Numerical values are based on the following values of fundamental constants: $h = 6{\cdot}623 \times 10^{-27}$, $c = 2{\cdot}99772 \times 10^{10}$, $k = 1{\cdot}3803 \times 10^{-16}$.) Thus, at 6,000 deg. the formula gives $\lambda_m = 4{,}829$ angstroms, which is towards the middle of the visible spectrum.

The derivation of the formula reminds us that the spectral concentration of energy is measured by the

amount lying between wave-lengths λ and $\lambda + d\lambda$. But one might adopt the equally valid interval between frequencies f and $f + df$, which is in fact more appropriate for certain kinds of apparatus. Although it is not well known that this would make a difference, the formula changes to

$$\lambda_m T = 0{\cdot}5098 \text{ cm. deg.},$$

the constant being increased by a factor 1·76. This substantial change moves the maximum for a 6,000 deg. body to 8,497 angstroms.

This is an infra-red wave-length not visible to the human eye. As the calculation is quite as valid as the one familiar in text-books, it runs counter to the widespread impression that the energy spectrum of sunlight has its maximum in the spectral band visible to the human eye.

This is one point of interest. If we return to the inquiry about the location of the maximum of the black-body energy spectrum, it must be concluded that Wien's law does not give a unique answer. The line of reasoning on which it is based leads to two different answers, according as one measures the radiation per unit of frequency or per unit of wave-length. This suggests that Planck's formula be re-examined for any further maximal properties, especially any which are invariant with change from a wave-length to a frequency basis.

Let $\Lambda = \log \lambda$ and consider the energy $E_\Lambda d\Lambda$ lying between Λ and $\Lambda + d\Lambda$. Let its maximum fall at $\Lambda_m = \log \lambda_0$. Consider also the energy between F and $F + dF$ where $F = \log f$. In this case the maximum clearly falls at the same wave-length λ_0 as in the first case. The reason is that dF and $d\Lambda$ represent fractional increments of f and λ, and thus maintain their ratio constant throughout the spectrum. Previously, when spectral intervals were measured in units of frequency or wave-length, the relative sizes of the two measures varied with frequency so that maximum energy per unit frequency interval was not a maximum per unit wave-length interval, and vice versa.

Now if one considers any function L, more general than *log*, and regards it in turn as a function of λ and then of f, the energy lying between L and $L + dL$ will in general not exhibit a maximum at the same wave-length in the two cases. But if it does, the wave-length is found to be λ_0 as before. In order that L should lead to a single maximum, it is necessary that $dL/d\Lambda = 0$ when $\Lambda = \Lambda_m$.

The maximum at λ_0 is thus unique in being free from the objection of altering when a change is made from a wave-length to a frequency basis. It falls where the energy per octave (or similar logarithmic interval) is a maximum. It may be located by differentiating Planck's formula with respect to the logarithm of either the frequency or the wave-length. A Wien-type law continues to hold for the maximum so defined, but in the form

$$\lambda_m T = 0{\cdot}3669 \text{ cm. deg.}$$

(This constant comes from the root of the equation $\exp.(-x) + \frac{1}{4}x - 1 = 0$, where $x = hc/k\lambda T$.)

The location of this natural maximum of the 6,000-deg. spectrum proves to be 6,115 angstroms, at the red end of the visible spectrum.

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Measurements of Lifetimes of Excited States of Atoms by the Method of Delayed Coincidences

We have adapted the method of delayed coincidences[1] to the investigation of lifetimes of excited states of atomic helium. Helium gas at a pressure of about 0·01 mm. mercury was excited by a beam of 40 eV. electrons, and the photons emitted in the subsequent de-excitation detected by means of an *E.M.I. VX* 5031 photo-multiplier, the wave-lengths corresponding to the various transitions being selected by means of Barr and Stroud interference filters. The intensity of the electron beam was modulated by means of a grid which was maintained at a potential sufficiently negative to cut off the beam completely except during the application of a positive voltage pulse of duration 2×10^{-8} sec. and repetition rate 10 kc./s. The helium atoms were therefore excited by short bursts of electrons. The voltage pulses from the photomultiplier, corresponding to the ejection of single electrons from its cathode, were amplified and applied to one side of a coincidence unit of resolving time 2×10^{-8} sec. The pulse used for modulating the electron beam was also applied to the other side of the coincidence unit through a variable length of 'Uniradio 57' cable. A coincidence was therefore registered only if the delay in this cable was equal to the interval between the electron burst and the subsequent emission of a photon, and for delays longer than the overall resolving time of the apparatus the variation of coincidence-rate with delay should show an exponential decrease, the decay constant being the reciprocal of the mean life of the excited state involved. We are satisfied that for the transitions referred to below, the conditions of our experiment are such that the effects on the apparent lifetime of recombination of ions and of cascade transitions from higher states are negligible.

It is desirable to test the performance of an apparatus of this sort by examining a transition the lifetime of which is believed to be much shorter than the resolving time of the apparatus, so giving what is usually called a 'prompt' curve. We have endeavoured to use for this purpose the 5016 A. line emitted in the transition $3\,^1P \rightarrow 2\,^1S$. The $3\,^1P$ level is expected to have a very short lifetime because it can also decay to the ground state with the emission of a quantum of wave-length 537 A., and this latter transition should be very fast because of the λ^{-3} factor in the theoretical expression for the transition probability. Theoretical calculations indicate that the mean life of the $3\,^1P$ level is about 2×10^{-9} sec. Results obtained with the 5016 A. line are represented by the two lower curves in Fig. 1, which shows the coincidence-rate plotted logarithmically as a function of the delay for pressures of 0·005 and 0·03 mm. mercury. For delays greater than $1{\cdot}5 \times 10^{-7}$ sec. the curves are linear, showing that the decay is exponential. The fact that the curves do not rise until the delay is 9×10^{-8} sec. is due to the transit time of the electrons in the photomultiplier.

The curve obtained at 0·005 mm. is appreciably narrower than that at 0·03 mm.; but even the former is significantly wider than is to be expected for a truly prompt transition, indicating that the apparent lifetime of the transition is greater than 10^{-8} sec. We believe that the reason for this increase in the apparent lifetime of the $3\,^1P$ level and its dependence on pressure lies in the phenomenon of imprisonment

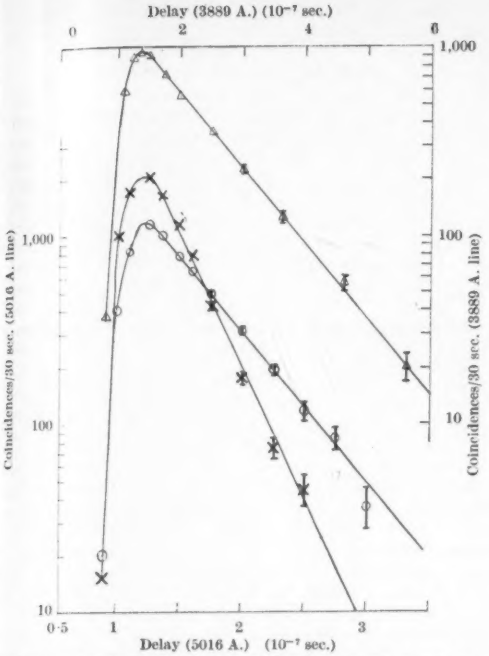

Fig. 1. ○—○—, 5016 A., $p = 0{\cdot}03$ mm. mercury; ×—×—, 5016 A., $p = 0{\cdot}005$ mm. mercury; △—△—, 3889 A., $p = 0{\cdot}03$ mm. mercury

of resonance radiation[2]. Because the 537 A. line is a resonance line, the time which atoms spend in the $3\,^1P$ level is considerably lengthened, and this is accompanied by an increase in the apparent lifetime of the $3\,^1P \rightarrow 2\,^1S$ transition. The linear portions of the curves correspond to exponential decays with mean lives of $2{\cdot}9 \times 10^{-8}$ and $5{\cdot}3 \times 10^{-8}$ sec., which agree well with the values calculated from Holstein's theory[3] of the imprisonment process for pressures of 0·005 and 0·03 mm. mercury respectively when allowance is made for the effect of the $3\,^1P \rightarrow 2\,^1S$ transition. We were unable to work at pressures lower than 0·005 mm. because, as was pointed out by Skinner and Lees[4], one consequence of the imprisonment process is that the intensity of the 5016 A. line is not proportional to pressure. At pressures low enough to make the apparent lifetime approach the natural lifetime, the intensity is so low as to be unusable with our present apparatus. For this reason we have been unable to obtain a truly prompt curve, but we are considering alternative ways of doing so.

As a transition the lifetime of which is expected to be long we have chosen the 3889 A. line emitted in the transition $3\,^3P \rightarrow 2\,^3S$. This would be expected to have a longer lifetime than the corresponding singlet transition because the $3\,^3P$ levels cannot decay to the ground-state. Results obtained with the 3889 A. line are represented by the top curve in Fig. 1. The shape of this curve was found to be independent of pressure, which is to be expected since triplet lines cannot be imprisoned. From the slope of the linear portion of this curve we estimate the mean life of the $3\,^3P$ triplet to be $(1{\cdot}08 \pm 0{\cdot}07) \times 10^{-7}$ sec.

Measurements of this sort are of interest because for light atoms lifetimes of states can be computed quantum-mechanically with moderate accuracy, so that a check on radiation theory is possible. Calculations of transition probabilities for helium have been made by Hylleraas[5], Goldberg[6] and Bates and Damgaard[7]. Taking the total decay constant of the $3\,^3P$ triplet to be the sum of the transition probabilities for the $3\,^3P \rightarrow 2\,^3S$ and $3\,^3P \rightarrow 3\,^3S$ transitions, we obtain the following values for the mean life τ:

	Hylleraas	Goldberg	Bates and Damgaard
$\tau \times 10^7$ sec.	1·18	0·83	0·97

Too much weight should not be attached to the results of Goldberg because he uses rather inexact wave-functions. Our experimental value is almost exactly the mean of the other two values; but this result is perhaps somewhat fortuitous in view of the uncertain accuracy of the theoretical calculations.

A full account of this work will be published elsewhere.

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June 5.

[1] See, for example, Bell, R. E., Graham, R. L., and Petch, H. E., *Can. J. Phys.*, **30**, 35 (1952).
[2] Mitchell, A. C. G., and Zemansky, M. W., "Resonance Radiation and Excited Atoms", 106 (Cambridge, 1934).
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Random Fragmentation

The problem of random fragmentation of a line into a finite number of N parts has received considerable attention, partly because of its application in assessing the randomness of radioactive disintegrations and cosmic ray events. For a line of length l the average number of fragments equal to or greater than x is[1]:

$$N(x) = N(1 - x/l)^{N-1}. \qquad (1)$$

This equation is readily applied to discuss[2] an idealized case of random fragmentation of area. Consider a rectangle of sides l_1 and l_2 (area $\Sigma = l_1 l_2$) and imagine it to be divided into subrectangles by drawing at random N_1 and N_2 lines respectively parallel to the two sides of the rectangle. If $N(S)$ be the average number of elements of area equal to or exceeding S, we have, using equation (1):

$$N(S) = \frac{N_1 N_2 (N_1 - 1)(N_2 - 1)}{l_1 l_2} \iint_{xy \geq S} \left(1 - \frac{x}{l_1}\right)^{N_1 - 2} \left(1 - \frac{y}{l_2}\right)^{N_2 - 2} \mathrm{d}x\mathrm{d}y$$

$$\sim - 2N_0 \left(\frac{S}{S_0}\right)^{1/2} K_1\left[2\left(\frac{S}{S_0}\right)^{1/2}\right], \qquad (2)$$

where $K_1(z)$ is the usual Bessel function of imaginary argument, $N_0 = N_1 N_2$ is the total number of elements and S_0 the average area of an element,

$$S_0 = \Sigma / N_0.$$

For $S \gg S_0$ we obtain the approximate relation:

$$N(S) \sim \pi^{1/2} N_0 \left(\frac{S}{S_0}\right)^{1/4} \exp\left\{- 2\,(S/S_0)^{1/2}\right\}. \qquad (3)$$

As already remarked, equation (2) has been obtained for an idealized case. It may not be unreasonable to expect that it would describe the essential features

of the observed fragmentation of plates, for example. We have found it to be the case for the fragmentation of glass plates; details will be published elsewhere.

It is an obvious step to extend the foregoing treatment to the case of random fragmentation of volume. Taking as before an idealized case of the random subdivision of a rectangular parallelepiped of volume Ω, we obtain, using equation (1), for the number of elements with volume equal to or greater than V,

$$N(V) \sim \frac{2\pi}{3^{1/2}} N_0 \left(\frac{V}{V_0}\right)^{1/3} \exp\left\{-3\,(V/V_0)^{1/3}\right\}, \quad (4)$$

where N_0 is the total number of fragments and V_0 the average volume of a fragment ($V_0 = \Omega/N_0$): this means that $\log N(V)$ and $V^{1/3}$ follow a nearly linear relation. If V_1 denotes the volume of the largest element, we have from equation (4), by putting $N(V) = 1$:

$$\left(\frac{V_1}{V_0}\right)^{1/3} = \frac{1}{3}\log\left(\frac{2\pi N_0}{3^{1/2}}\right) + \frac{1}{9}\log\,(V_1/V_0). \quad (5)$$

It is of interest to consider the application of (4) to the cosmological problem of the mass-distribution of stars in the galaxy. A similar consideration should apply, and possibly even more plausibly, to the problem of the mass-distribution of galaxies. Fig. 1, in which the values given are based on the data (pp. 334, 367) taken from Baker, R. H., "Astronomy" (D. Van Nostrand Co., New York, 1950), is a plot of $\log N(M)$ against $M^{1/3}$ (M is in units of the solar mass) where $N(M)$ is the (relative) number of stars of mass equal to or exceeding M. What is directly known from observation is the distribution of stars according to their intrinsic luminosity—the luminosity function. The use of the observed mass–luminosity relation gives the distribution of stars according to mass, that is, $N(M)$ as a function of M. It will be observed that the points ($\log N(M)$, $M^{1/3}$) lie almost on a straight line. This makes it likely, as is envisaged in some current cosmological theories, that stars have been formed as a result of some sort of a random fragmentation of dense pre-stellar matter (at an epoch about 3×10^9 years ago). The process can be conceived as equivalent to fragmentation of volume, because at the epoch of fragmentation the material could be regarded as of almost uniform density (of the order of nuclear density of matter). It is indeed remarkable that the distribution law (4) accords as well as it does with the observed distribution of stars in the Milky Way. A more detailed account of this investigation will appear in the *Proceedings of the National Institute of Sciences, India*.

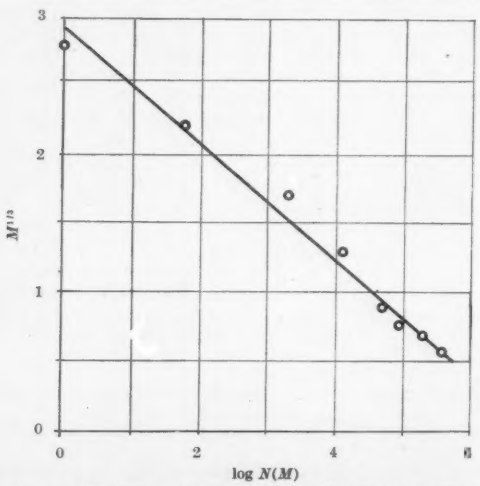

Fig. 1. $N(M)$ denotes the relative number of stars of mass equal to or exceeding M. M is stellar mass in units of the solar mass

F. C. Auluck
D. S. Kothari

University of Delhi.
May 27.

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Thermoelectric Power and the Bauschinger Effect

It has been proposed[1,2] that the Bauschinger effect which occurs in face-centred cubic metals after a plastic strain exceeding 1 per cent might be attributed to the rearrangement of dislocations at the beginning of the reversal of strain. If we rather crudely reckon that changes of thermoelectric power and electric resistance are measures of the total disorder in a lattice, then these should remain constant during the Bauschinger strain, though increasing during previous and subsequent plastic strain, because during the Bauschinger strain the total disorder in the lattice is not increasing, but merely being re-arranged.

Preliminary measurements of the thermoelectric power of copper now support this view. We have measured the thermoelectric power of 99·9 per cent copper as a function of plastic shear strain, using torsion and reverse torsion of a thin-walled tube. The change of thermoelectric power during a unidirectional plastic shear strain of 1 per cent is very small, and the change during the Bauschinger strain is even smaller, so that even when all precautions are taken the overall accuracy is not as high as might be desired. In our experiments the ends of the specimen are maintained at 10° and 30° C. respectively, and the thermal e.m.f. is measured to an accuracy of 5×10^{-11} V./deg. C. by a null method using a Paschen galvanometer as detector.

Six tests were carried out. Each specimen was first deformed by the application of a stress $+\sigma_0$, then unloaded, and a negative stress applied in suitable increments until it exceeded $-\sigma_0$. In these tests the stress σ_0 had values between 550 kgm./cm.^{2} and 1,100 kgm./cm.^{2}, corresponding to strains between 10 and 30 per cent. In each test the mean rate of increase of thermoelectric power with plastic shear strain during the Bauschinger strain (that is, between $+\sigma_0$ and $-\sigma_0$) was compared with the mean rate of increase after $-\sigma_0$ was passed, and their ratio determined. This ratio is found to lie within the range 29 ± 21 per cent. We therefore conclude that during the Bauschinger strain the increase of disorder in the lattice is decidedly smaller than during ordinary unidirectional plastic strain.

It may be argued that though the Bauschinger strain is attributed to the rearrangement of dislocations, changes in thermoelectric power are more probably due to changes in the number of vacancies and interstitial atoms present, as suggested by Seitz[3] for the case of electric resistance. This difference is of no significance if we assume that vacancies and interstitial atoms are formed as a result of the intersection of screw dislocations; during the Bauschinger strain the dislocations are regarded as

each moving a distance equal to their mean distance apart[1], so that to a first approximation no dislocations cross each other, and relatively few vacancies or interstitial atoms are generated.

R. L. Woolley
Natural Philosophy Department,
St. Andrews University.
June 2.

[1] Woolley, R. L., *Phil. Mag.*, **44** 597 (1953).
[2] Polakowski, N. H., *Nature*, **168**, 838 (1951).
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Simplified Particle-size Calculations

Particle-size analysis by microscopical methods provides large samples of measurements which then need numerical analysis to give estimates of average diameters, specific surface, etc. When, as is often the case, particle sizes are log-normally distributed[1-4], tedious summation of powers of the sizes can be avoided if the cumulative distribution is plotted on log-probability paper[1,4]. From this, estimates of the mean, $\bar{y}$, and standard deviation, σ, of the distribution of log sizes can be read off; from these two values can be calculated any of the many kinds of average which are used in this work. If D be such an average, the general equation for this purpose is:

$$\log D = \bar{y} + c\,\sigma^2, \qquad (1)$$

where the value of c depends only on the kind of average, D, that is being calculated[1,4].

Even this calculation can be avoided, and a simple completely graphical method substituted with little loss of precision.

If we regard the (linear) abscissa scale (see Fig. 1) as the normal deviate z with origin at the 50 per cent point, the line drawn on probability paper has the equation:

$$Y = \bar{y} + \sigma z. \qquad (2)$$

If one unit of y (between particle sizes of 1 and 10, or 10 and 100) occupies a distance A on the paper and one unit of z a distance B (the distance between the 0·1 per cent and 99·9 per cent abscissæ is $6{\cdot}2B$), equation (2) becomes:

$$Y = \bar{Y} + \frac{A}{B}\,\sigma Z, \qquad (3)$$

where Y, Z are co-ordinates in units of distance and $\bar{Y}$ is then the ordinate corresponding to $\bar{y}$.

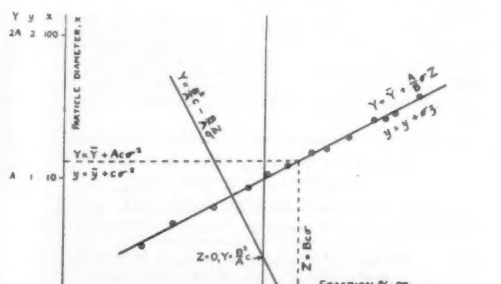

Fig. 1. Graphical method using logarithmic probability paper

The line through the point $Z = 0$, $Y = \frac{B^2}{A}c$ ($z = 0$, $y = \frac{B^2}{A^2}c$) normal to (3) will be:

$$Y = \frac{B^2}{A}c - \frac{B}{A}\frac{Z}{\sigma}, \qquad (4)$$

and will meet the Z-axis at $Z = Bc\,\sigma$.

The ordinate of (3) corresponding to this value of Z, namely,

$$Y = \bar{Y} + Ac\,\sigma^2,$$

is equivalent to: $y = \bar{y} + c\,\sigma^2 = \log D$, and gives the average that is sought.

The scale-factors A, B are constant for any one kind of probability paper, and c depends only on the average diameter being estimated. Hence the point $Z = 0$, $Y = \frac{B^2}{A}c$ is independent of the sample of sizes and can be determined beforehand for each average diameter.

There are occasions also when very approximate results will suffice and are needed rapidly; the number of particles measured and the calculation can then both be greatly reduced. It is necessary only to pick out and measure the largest particle and the smallest particle of the sample and to make a rough estimate of the total number, n, of particles that could have been measured.

If y_1, y_n are the logarithms of the largest and smallest particle sizes, their mid-range $\frac{1}{2}(y_1 + y_n)$ provides an estimate of the mean $\bar{y}$, and from the range the standard deviation σ can be estimated as $\frac{1}{w}(y_1 - y_n)$, where w is roughly the expected range in samples of n. The value of w depends on n and can be chosen from the following table, which is based on Tippett's table[5] and is sufficient for this approximate method.

n	w
20–35	4
35–70	4½
70–140	5
140–300	5½
300–700	6
700–1,700	6½
1,700–3,000	7

It must be borne in mind not only that this method is approximate and not efficient but that, as in all cases where range and mid-range are used as estimators, the results can be affected, without it being known, either by truncation of the sample or by the presence in the sample of exceptionally large or small particles which do not belong to the population of particles under consideration. Thus it is recommended that this method is best used as a rough check on calculations by some longer method, or for obtaining quickly approximate information from a sample of a material about which something is already known, so that an unexpectedly large or small estimate of σ can be recognized and regarded with suspicion.

C. H. Leigh-Dugmore
Research Centre,
Dunlop Rubber Co., Ltd.,
Birmingham 24. April 22.

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[2] Dalla Valle, J. M., "Micromeritics" (Pitman Pub. Corp., New York, 1943).
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[5] Tippett, L. H. C., *Biometrika*, **17**, 364 (1925).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Tuesday, September 21—Friday, September 24

INSTITUTION OF NAVAL ARCHITECTS (at the Electric Hall, Torquay)—Annual Meeting.

Wednesday, September 22—Friday, September 24

NATIONAL SMOKE ABATEMENT SOCIETY (at Scarborough).—Twenty-first Annual Conference.

Thursday, September 23

OIL AND COLOUR CHEMISTS' ASSOCIATION (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 10.30 a.m.—Symposium on "Rheology and Settlement of Pigmented Systems".

Friday, September 24

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, The University, Sheffield 10), at 11 a.m.—Scientific Papers.

PHYSICAL SOCIETY (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Sir Geoffrey Taylor, F.R.S.: "Diffusion and Mass Transport in Tubes" (38th Guthrie Lecture).*

Friday, September 24—Saturday, September 25

SOCIETY OF LEATHER TRADES' CHEMISTS (in the large Chemistry Lecture Theatre, The University, Leeds)—Annual Conference.

Friday, September 24

At 2 p.m.—Prof. J. T. Randall, F.R.S.: "Observations on the Collagen System" (Sixth Procter Memorial Lecture).

Friday, September 24—Monday, September 27

ASLIB (at Church House, Westminster, London, S.W.1)—Annual Conference.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

CHEMISTS (with honours degree in chemistry or chemical engineering or A.R.I.C. or A.M.I.Chem.E.), to carry out work on the supply of potable water, disposal of radioactive solid and liquid waste, control of pickling and plating shops and other industrial chemical processes—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Berkshire, quoting 2/103/140 (September 24).

DEMONSTRATOR IN CHEMISTRY AND BIOLOGY—The Registrar, The Technical College, Sunderland, Co. Durham (September 25).

PHYSICIST (with good honours degree in physics and at least two years research experience, and preferably with some practical acquaintance with electronics) for work in the field of psycho- and physio-acoustics—The Secretary, Institute of Laryngology and Otology, 330–332 Gray's Inn Road, London, W.C.1 (September 25).

EXPERIMENTAL OFFICER (with university degree in an approved scientific subject, or equivalent qualifications, and preferably with qualifications or experience in library and information work and a knowledge of foreign languages) IN THE SCIENTIFIC DEVELOPMENT AND FORENSIC SCIENCE DEPARTMENT, Ministry of Commerce—The Secretary, Civil Service Commission, Stormont, Belfast (September 27).

SCIENTIFIC OFFICER (with an honours degree in chemistry and post-graduate experience in agricultural chemistry, or an honours degree in agricultural chemistry) IN THE CHEMICAL RESEARCH DIVISION, Ministry of Agriculture, for research work and possibly for teaching duties in the Faculty of Agriculture, Queen's University, Belfast—The Secretary, Civil Service Commission, Stormont, Belfast (September 27).

PRINCIPAL ASSISTANT ENGINEER (with honours degree or Corporate Membership of the I.Mech.E., or I.E.E., and with sound knowledge of power station design) in the Station Development Sub-Branch, for work in connexion with the siting, planning and negotiation of facilities and consents for new and extended power stations—The Director of Establishments, British Electricity Authority, Winsley Street, London, W.1, quoting T/518 (September 28).

SENIOR LECTURER (with high academic and research qualifications, and ability to teach to special (honours) degree standard) IN ORGANIC CHEMISTRY—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (September 28).

ADVISORY OFFICER (with high scientific qualifications and considerable postgraduate experience in animal husbandry) IN ANIMAL HUSBANDRY, to assist the advisory services with animal husbandry problems and to carry out investigational work arising therefrom—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (September 30).

LECTURER or ASSISTANT LECTURER (with honours degree in physical oceanography, mathematics or physics, and prepared to spend several weeks each year at sea) IN THE DEPARTMENT OF OCEANOGRAPHY—The Registrar, The University, Liverpool (September 30).

RESEARCH ASSISTANT (graduate in science (biochemistry)) for work on the metabolism of vitamin C in relation to rheumatic disease—The Secretary, Rheumatic Unit, Northern General Hospital, Ferry Road, Edinburgh (September 30).

LECTURER (with good honours degree in electrical engineering and should preferably have completed a graduate apprenticeship) IN ELECTRICAL ENGINEERING—Head of the Electrical Engineering Department, City and Guilds College, London, S.W.7 (October 1).

ASSISTANT METALLURGIST with knowledge of copper and its alloys, and preferably with the ability to write on technical matters—The Secretary, Copper Development Association, Kendals Hall, Radlett, Herts.

ASSISTANT SURVEYORS (with experience in carrying out topographical surveys by plane table and tacheometer) IN THE GOVERNMENT OF KENYA AGRICULTURAL DEPARTMENT—Crown Agents, 4 Millbank, London, S.W.1, quoting M2B/40423/TA.

CHEMISTS (science graduates, with first- or second-class honours degrees) in the London Transport Central Laboratory, Chiswick, for work on the development of tests for lubricants and investigations on the performance of lubricants under service conditions—Staff Officer, London Transport, 55 Broadway, London, S.W.1, quoting F/EV/508.

ENGINEERING SURVEYOR (with experience in the use of the level, theodolite, tacheometer and plane table sufficient to carry out surveys for engineering projects) with the Government of Tanganyika—Crown Agents, 4 Millbank, London, S.W.1, quoting M2B/30471/TA.

HEAD (with teaching, industrial or research experience) OF THE CHEMISTRY AND APPLIED CHEMISTRY DEPARTMENT—The Principal, Royal Technical College, Salford 5.

HEADS (with honours degree in chemistry, metallurgy, physics or engineering, or equivalent qualifications, with experience in the control and administration of applied research, and preferably with experience of the techniques and precautions involved in the handling of highly toxic and radioactive materials) OF LABORATORIES OF THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, for duties including the administration and management of the laboratories, the direction of the scientific work and liaison with the operations and design groups—United Kingdom Atomic Energy Authority, Industrial Group Headquarters, P.O. Box 19, Risley, Warrington, quoting 606.

LECTURERS and ASSISTANT LECTURERS IN PHYSICS, MINERALOGY, CHEMICAL, ELECTRICAL, MECHANICAL and MINING ENGINEERING, at the University of Indonesia—The Cultural Attaché, Indonesian Embassy, 38 Grosvenor Square, London, W.1.

ORGANIC CHEMIST for the National Coal Board, North-Eastern Section, for work on the investigation of problems connected with by-products from coke oven plants—Divisional Chief Scientist, Roundwood Colliery, Parkgate, Rotherham, Yorkshire.

PHYSICIST (with a degree in physics and the ability of applying experimental techniques to the solution of fluid problems in the iron and steel industry) IN THE FLUID DYNAMICS SECTION of the Physics Department—Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

PRINCIPAL SCIENTIFIC OFFICERS or SENIOR SCIENTIFIC OFFICERS (with first- or second-class honours degree in physics and with some years postgraduate research experience in mass spectrometry or nuclear physics), to undertake research and development work—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting 230/WGE/2.

RESEARCH ASSISTANT (with qualifications in mathematics or physics and preferably with experience of either X-ray crystallography or large-scale computing) IN THE DEPARTMENT OF INORGANIC AND STRUCTURAL CHEMISTRY, for work on the preparation and carrying out of programmes on crystallographic calculations—Prof. E. G. Cox, Department of Inorganic and Structural Chemistry, The University, Leeds 2.

RESEARCH ASSISTANT IN THE DEPARTMENT OF PHYSICS, for work on an X-ray investigation of ternary alloy systems with adamantine structure—The Registrar, The University, Nottingham.

RESEARCH ENTOMOLOGIST (with an honours degree in biology and with at least two years postgraduate training in scientific research, specializing in entomology, and preferably with statistical training or interest in statistics) in the West African Institute for Trypanosomiasis, to undertake research upon the behaviour, breeding and longevity of the tsetse fly under controlled climatic conditions—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.197/198/04.

SCIENTIFIC ASSISTANT (with an honours degree in biological sciences and able to write correct English, and preferably with some knowledge of foreign languages), for work including the collation, abstracting and reviewing of biological literature—The Director, Commonwealth Bureau of Plant Breeding and Genetics, School of Agriculture, Cambridge.

SCIENTIFIC OFFICER (with first- or second-class honours degree in physics, with experience in the detection and measurement of nuclear radiations and a good practical and theoretical knowledge of electronic counting techniques), to work in conjunction with a group of chemists engaged in research on radioactive materials—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting 161/WGE/34.

SCIENTIFIC OFFICERS (with first- or second-class honours degree in physics or electrical engineering), at Royal Air Force Stations in Buckinghamshire and Norfolk, for operational research duties and theoretical studies in communications and general electronics—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A109/54A.

SENIOR LECTURER or LECTURER IN PATHOLOGY—The Registrar, The University, Sheffield.

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